# Eurasian Economic Union, Regional Integration and the Gravity Model

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# Summary

Many years ago, Dutch economist and Nobel laureate, Jan Tinbergen introduced the so-called gravity model of international trade. With this model he brought the Newtonian law of universal gravitation to the international trade theory, stipulating that trade between two countries is proportional to the product of the countries economic size (in gross domestic product) and inversely proportional to the distance between them. Today, the gravity model is considered as one of the most successful empirical models in modern trade theory and has been devoted an extensive attention by researchers ever since Tinbergen.

The purpose of this master thesis is to discuss how the gravity model of international trade can be used to estimate the effects of economic integration agreements (EIAs) on member countries' trade flows. This is discussed with reference to Eurasian regional integration between three post-Soviet countries of Belarus, Russia and Kazakhstan - the Eurasian Economic Union. I review what is the core definition of regional integration and have an in-depth look at the history of Eurasian region, what have been the prerequisites for this integration and what are the economic characteristics of member countries.

I study the theory of gravity model, both its theoretical and econometrical methodology, although limiting my discussions to what is relevant for my own estimations. In this respect I investigate the theoretical application of the model given by Anderson & Wincoop (2003) and then further discuss the different empirical approaches, especially emphasising the Poisson Pseudo Maximum Likelihood approach by Silva & Tenreyro (2006). With this I try to eliminate two out of three most common empirical issues in gravity literature - heteroskedasticity in error terms and omission bias (the third being reverse causality).

In order to study the effect the Eurasian Economic Union potentially has on its member countries' trade flows I construct an independent dataset. I use data on country specific characteristics (such as real export flows, real GDP, cultural and historical ties) and economic integration agreements (EIAs) and run my own regressions based on the discussion of both the theoretical and empirical aspects of the gravity model. My results and data confirm the general finding that being a member of an economic integration agreement leads to an increase in a country's international trade flows. My estimations show that membership in the Eurasian Economic Union increases members' trade flows by approximately 150%. This high coefficient value is supported by my combined dataset on export flows between these member countries during years 2010-2013.

# Acknowledgements

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First and foremost I would like to express my greatest acknowledgement to my supervisor, Karen Helene Ulltveit-Moe, Professor at the University of Oslo and expert in international economics and trade. Her knowledge, comments and suggestions have been of utmost value for my thesis. Credit is due to Marcus Gjems Theie, a former fellow student at the university, for providing me with valuable input and comments at the beginning of the whole process. Special thanks and appreciation to Saliha, my partner in crime, for proofreading the thesis and for having been a wonderful friend and co-student. I also want to extend my warm appreciation to my friends Minda and Karen, for their love, encouragement, for embracing me when I needed them most and not failing to be there for me.

My parents deserve my deepest gratitude and I dedicate this work to them - the true roses of my life. Their enthusiasm and sincere faith in me have guided me throughout my entire university experience and I would not be where I am today without their love and support. I hope that I have made them proud.

At last, but far from least, I want to thank my wonderful boyfriend Adam. He was and is my anchor on which I can rely again and again. I am indebted for his tender support and patience, love and motivation.

I bear sole responsibility for any errors or inaccuracies in this thesis.

# Contents

# 1 Introduction

During the last few decades there has been large integration of world economy and several viable integrations projects have been implemented so as to reduce or totally eliminate different economic frictions between nations. As of 15 June 2014, the World Trade Organization (WTO) has received 585 notifications of regional trade agreements, and 379 of these are in force. Trade agreement is a wide treaty on tax, tariff and trade between several countries, often of preferential and free types, established in order to reduce (or eliminate) tariffs, quotas and other trade restrictions on items traded between agreement's signatories.

The regional economic integration agreement in focus of my thesis is Eurasian Economic Union. This is a newly upcoming economic integration project between post-Soviet countries Belarus, Kazakhstan and Russia. The Union is fully implemented as of 1 January 2015, so in period of writing this thesis (except for first two weeks of January) the Eurasian Economic Union does not exist in its final form, but there are two other projects that have been realized for a while now - Customs Union (since 2010) and Single Economic Space (since 2012) between given countries. This thesis sets out to discuss the relationship between this economic integration agreement and member countries' international trade, a relationship best evaluated by use of so-called gravity model of trade. This model has become both an empirical and theoretical success and is widely used by international trade researchers as it accurately predicts trade flows between countries for many goods and services over period of time. Gravity model's comparative advantage is in its ability to use real data to assess the sensitivity of trade flows with respect to policy factors researchers are interested in.

The Eurasian regional integration is still young and fragile, but very ambitious in its perspectives and has been developing at high speed for the past four years. Consisting of three countries that are perceived by many as authoritarian, built on "friendship" of three highly authoritarian leaders, many researchers consider this project short-lived and doomed to failure, while others see a clear potential, as long as specific trade and welfare increasing measurements are taken. It is not my intend to evaluate whether or not this Union will have positive or negative welfare or economic effects, I do not look at these implications of it. Main point of my thesis is to use a well-defined model of international trade and applying it with given dataset estimate and analyse what effects on bilateral trade flows of member countries the above given two projects (Customs Union and Single

Economic Space) have had, and from this speculate, given the trade theory, what effects there are to be expected from a full-functioning Eurasian Economic Union.

There exists a considerable amount of empirical and theoretical literature on gravity model, that has been focus of trade researchers ever since it was introduced by Jan Tinbergen in 1962. In short, the traditional gravity equation of international trade is a model, which explains trade flows between exporter and importer GDP's and trade frictions in form of geographical distance between the countries. For long time gravity model lacked a proper theoretical foundation, although it was considered as one of the most empirically successful in economic literature. Anderson and van Wincoop (2003) accounted for this theoretical issue by introducing price indices for importer and exporter countries as multilateral resistance terms. These terms mean that trade frictions with all other trade partners outside of the trade agreement also affect the signatories bilateral trade and hence need to be included in the equation. The problem is that these terms are almost impossible to observe and hence there are a range of econometrical approaches that account for this issue. Fixed effects estimation (suggested by e.g. Feenstra, 2004), first order Taylor approximation of the multilateral resistance terms by Baier & Bergstrand (2009) are the two most important ones. To account for issues of heteroskedasticity and zero observations in trade Poisson Pseudo-Maximum Likelihood estimation has been introduced by Silva & Tenreyro (2006) as a simple solution to this. All this makes clear that the gravity model is an obvious choice in evaluating the effect of Eurasian regional integration on trade flows and I review in-depth these different approaches, whilst regarding only those relevant for my thesis.

The structure of the thesis is as follows: Chapter 2 specifies economic integration agreements and looks closely at the Eurasian regional integration, the history of the region, reviewing in short what are the prerequisites for such integration. Chapter 3 introduces the gravity model. Here I summarise the literature on gravity equation and the studies dealing with the problems of theoretical and empirical characteristics. I review the model in its basic and theoretical forms, then further study the empirical methodology of the theoretical model. In chapter 4 I apply the theoretical model and discuss the results of my own estimations. I use a comprehensive dataset consistent of different characteristics and exports flows of 45 different countries over four years. I look at how different trade agreements, and especially that of Eurasian Economic Union, affect the bilateral exports flows for members of these agreements. Chapter 5 summarised and concludes my thesis.

# 2 Economic Integration Agreements

## 2.1 Defining regional integration

Regionalism has long become a dominant factor in the development of world trade. As a result of this, during the last decades there has been a large growth in the number of international economic integration agreements. In general, economic integration agreements (EIAs) are treaties between nations that aim to reduce policy controlled barriers to the flow of goods, capital, labour and services between countries. Most of EIAs tend to be regional trade agreements (RTAs) and most tend to be free (or preferential) trade agreements (FTAs). Today there exists few successful trade agreements or economic unions, European Union would be the sole winner, having been able to establish a common monetary union, harmonise legislations, developed policies ensuring free movement of people, goods, services and capital, and maintaining common policies on trade and regional development. European Union has become a manual for other attempts of similar regional economic integration.

Economic integration between countries can take on different forms depending on the objectives and goals of the member states. The World Trade Organization (WTO) distinguishes between 3 types of regional economic integration[1]:

1. ***Customs Union***, which under GATT Article XXIV, paragraph 8a, reads as: "A customs union shall be understood to mean the substitution of a single customs territory for two or more customs territories, so that (i) duties and other restrictive regulations of commerce are eliminated with respect to substantially all the trade between the constituent territories of the union or at least with respect to substantially all the trade in products originating in such territories, and (ii) subject to the provisions of paragraph 9, substantially the same duties and other regulations of commerce are applied by each of the members of the union to the trade of territories not included in the union";

2. ***Free trade area***, which under the same GATT article, paragraph 8b, reads as "a group of two or more customs territories in which the duties and other restrictive regulations of commerce are eliminated on substantially all the trade between the constituent territories in products originating in such territories";

[1] http://www.wto.org/english/res_e/booksp_e/analytic_index_e/gatt1994_09_e.htm

3. ***Economic Integration Agreement***.

The Organization for Economic Cooperation and Development (OECD) defines[2] a regional trading agreement as an agreement among governments to liberalize trade and possibly to coordinate other trade related activities. There is distinction between four principal types of regional trading agreements:

1. *Free trade area*: a grouping of countries within which tariffs and non-tariff trade barriers between the members are generally abolished but with no common trade policy (the so-called common external tariff, CET) toward non-members. The North American Free Trade Area (NAFTA) and the European Free Trade Association (EFTA) are examples of free trade areas.

2. *Customs Union*: an arrangement among countries in which the parties do two things: (i) agree to allow free trade on products within the customs union, and (ii) agree to a common external tariff (CET) with respect to imports from the rest of the world.

3. *Common Market*: a customs union with provisions to liberalize movement of regional production factors (labor and capital).

4. *Economic Union*: a common market with provisions for the harmonization of certain economic policies, particularly macroeconomic and regulatory. The European Union is an example of an economic union.

It is obvious from these definitions that a classification of a regional integration agreement assumes several degrees of depth, all dependent on what the goals, aims and wishes are of the involved partners. It also implies that certain elements of liberalization of a common economic space are added to the previous level of integration, and in this way the integration project evolves. These elements can be summarised in four following points:

1. elimination of tariffs and large number of non-tariff barriers between member countries (areas of free-trade or sectoral free trade);

2. establishment of a common external tariff (CET) with respect to imports from rest of the world;

[2]http://stats.oecd.org/glossary/detail.asp?ID=3130

3. policy harmonization with regards to competition, fiscal, monetary, structural and social politics;

4. unification of economic politics and creation of supranational bodies (economic and political union).

The main focus of my thesis, the Eurasian Economic Union, is an integration project that the three founding member states - Russia, Kazakhstan and Belarus - have been working on it for several years now, taking all the necessary steps given above, and at this point in time are in the final process of unification of their economic policies and establishment of fully functional economic union. There are many uncertainties regarding this project and it is not my intend to give a well-defined answer to whether or not this Union will succeed or fail. Given the economic and econometrics tools at hand, my intend is to analyse what kind of effect Customs Union and the Single Economic Space of the Eurasian regional integration has so far had on trade flows of member countries and if there are any positive outcomes to be expected, in pure trade terms. I wish to emphasise that my estimations and discussions are limited to what is available and that there has yet not been, to my best knowledge, a proper empirical evaluation of Eurasian regional integration and hence I do not have any other studies to compare my results to. Nonetheless I believe that, given the history of the region, the existing theory of international trade and the data at hand, the estimated effects are to be assumed to yield a realistic picture of the current development, although I am, of course, fairly cautious in my interpretation of the results.

In the following subsections I introduce the idea behind Eurasian regional integrations - the Eurasian Economic Union (EEU) - what it is and what is the history behind it. I review recent discussions by scholars who analyse the project both in economic and political terms, and try to set it in a perspective of international theory of trade creation and trade diversion.

## 2.2 Eurasian regional integration

On October 3rd 2011, then the prime minister of Russia, Vladimir Putin, wrote an article for the Russian newspaper Izvestia [3], ambitiously titled "***New integration project for Eurasia, a future born today***", in which he supported and embraced an idea of a

[3]http://izvestia.ru/news/502761

new geopolitical project on the post-Soviet space, called Eurasian Economic Union, that would unify economies of Belarus, Kazakhstan and Russia. And so it goes.

> "*A major integration project kicks off on January 1st 2012, the Single Economic Space between Russia, Belarus and Kazakhstan. A project that, without any exaggeration, is a historic landmark not only for our three countries, but also for all countries on the post-Soviet space. On July 1st 2011 controls over movements of goods were lifted at the internal borders of our three countries, thereby completing the formation of a full-fledged single customs territory with clear prospects for implementing the most ambitious business initiatives. Now we are taking steps from the Customs Union towards a Single Economic Space. Creating a huge market with more than 165 million consumers, with unified legislation, free movement of capital, labor and services. At the time it took 40 years for Europeans to go from the European Coal and Steel Community to the full-fledged European Union. The creation of the Customs Union and of the Single Economic Space is much more dynamic, since it takes into account previous experience of the EU and other regional associations. We see their strengths and weaknesses. And in this is our obvious advantage that allows us to avoid errors and to prevent reproduction of all sorts of bureaucratic canopies.* "

### 2.2.1 History

In 1991 the Soviet era was put to an end after the Belavezha Agreement [4] was signed by three of the four republics-signatories of the Treaty on the Creation of the Union of Soviet Socialist Republics (USSR), and it was announced that the Commonwealth of Independent States (CIS) would be established in its place. This was the first attempt to reintegrate the post-Soviet republics on a new, fresh basis. Several, non-viable integration initiatives were formed on the space of the collapsed Soviet Union. But the idea to try to keep what is good from the Soviet Union in the CIS and to get rid of all that is bad without really revising the grounds of the association and reflecting over the new geopolitical realities was originally stillborn. The formality and the futility of the CIS was repeatedly stated by it´s members, but attempts to breathe life into it were in general useless. Then, the previous Soviet republics began to try to find a more pragmatic alliance, which resulted

[4] http://www.prlib.ru/en-us/History/Pages/Item.aspx?itemid=749

in a series of new regional integration initiatives.

Historically[5] the attempts to unify the post-Soviet region have been as follows:

- In 1995 leaders of Kazakhstan, Russia, Belarus, and later Kyrgyzstan, Uzbekistan and Tajikistan signed the first agreement on the establishment of Customs Union, which on 29 March 1996 was transformed into Eurasian Economic Community (EurAsEC). It was established for an effective promotion of the process of formation of Customs Union and of Single Economic Space. The Eurasian Economic Community was officially signed on 10 October 2000 and it came into force on 30 May 2001. In December 2003 the EurAsEC was granted observer status at the UN General Assembly.

- In August 2006, at the EurAsEC Interstate Council, a principal decision was made to establish a Customs Union between only three countries - Belarus, Kazakhstan and Russia.

- On 6 October 2007 in Dushanbe, capital of Tajikistan, leaders of Kazakhstan, Belarus and Russia signed a treaty on the establishment of a single customs territory and the concept of the Customs Union. Action plan for the formation of the Customs Union was designed for three years. It was also decided to form Customs Union Commission - a supranational body. Russia got 57% of the votes in the Commission, while Kazakhstan and Belarus - 21.5% each.

- In 2009 the Customs Union Commission came into force. Several documents were signed that formed the legal basis of the Customs Union of Belarus, Kazakhstan and the Russian Federation, including the Treaty on Customs Code of the Customs Union, agreement on Community's Court, which was vested with an authority to resolve legal disputes within the Customs Union. A plan of action for the formation of the Single Economic Space between Belarus, Kazakhstan and the Russian Federation was approved.

- On 28th November 2009 a meeting was held in Minsk between presidents Dmitry Medvedev (Russia), Alexander Lukashenko (Belarus) and Nursultan Nazarbayev (Kazakhstan) regarding establishment of a common customs area on the territory of Russia, Belarus and Kazakhstan from 1 January 2010.

[5]https://en.wikipedia.org/wiki/EurasianEconomicCommunity

- In June 2010 Belarus confirmed that the Customs Union will be launched in the trilateral format with Customs Code of the Customs Union entering into force.

- On July 1st 2010 the Customs Code became applicable at the territory of Russia and Kazakhstan. On July 6th 2010 the Customs Code came into force on the entire territory of the Customs Union.

- In December 2010, at the summit of the Eurasian Economic Community in Moscow, an agreement was reached on establishment of the Eurasian Economic Union on the basis of the Common Economic Space of Belarus, Kazakhstan and Russia. A single market for the Eurasian Customs Union came into effect in January 2012, the Single Economic Space. The Single Economic Space implies removal of most trade barriers with some common policies on product regulation, freedom of movement of factors of production (such as capital and labor), and also of enterprise and services.

- In October 2011 the Free Trade Agreement within CIS was signed by Russia, Belarus, Kazakhstan, Armenia, Ukraine, Kyrgyzstan, Moldova and Tajikistan, and ratified by Russia, Belarus, Ukraine and Armenia in 2012. The CIS free trade agreement is not the same as the Customs Union between Russia, Kazakhstan and Belarus, these are two different integration projects, and three countries in focus of my thesis are members in both of them.

- On 10 October 2014 state leaders of Russia, Belarus, Kazakhstan, Kyrgyzstan and Tajikistan signed the documents on the Abolishion of the Eurasian Economic Community (EurAsEC). This association ceases to operate in connection with the start of operation of the Eurasian Economic Union from January 1, 2015.

- On 10 October 2014 Armenia officially joined the Eurasian Economic Union. Eurasian "Trio" after the addition of Armenia became a "Quartet".

From here on I refer to Eurasian Economic Union as Eurasian regional integration, consistent of Customs Union established in 2010 and of Single Economic Space, established in 2012. In the following subsection I give a brief introduction of the three countries and then look at why exactly this regional integration project has probability of succeeding, at least seen in reference to all other previous attempts.

### 2.2.2 Countries Economic Characteristics

Only two years prior to joining WTO in 2012, Russia formed the Eurasian Customs Union with Belarus and Kazakhstan. Even though all these three countries have their past in the Soviet era and to this day remain authoritarian regimes, they still have different economic models (see figure 1 for overview of countries key economic indicators). Russia is a classical example of state capitalism, with big monopolies and state controlled large oil sector, growing fat on raw material exports. The economy of Belarus is weak and largely dependent on Russia, on its loans and non-repayable subsidies. The country survives on exports of mid-level engineering products to the Russian market. Figure 2 shows that 38.14% of Belarus' exports in 2012 was of mineral products, such as refined and crude petroleum, and also petroleum gas. The country also imports just as much, and even more - 40.57% of total Belarus imports in 2012 are of mineral products (see figure 3). This is according to Observatory of Economic Complexity[6], which also states Russia as Belarus' top import origin and export destination. Kazakhstan's economy is one of the strongest and fastest growing in Central Asia and has experienced steady growth since the financial crisis of 2008-2009. Much as Russia, Kazakhstan has based its economy on exports of raw materials, the country is second after Russia in the region in oil exports.

**Figure 1:** Economic indicators for Eurasian Economic Union

| | **Russia** | **Belarus** | **Kazakhstan** |
|---|---|---|---|
| Population in millions | 143, 5 | 9, 46 | 17, 04 |
| GDP in billion current US$ | 2096, 77 | 71, 71 | 224, 41 |
| GDP per capita in current US$ | 14 612 | 7 575 | 13 172 |
| Exports in million US$ | 82 510 | 37 203 | 527 265 |

In PPP terms, Russia accounts for 86% of the Eurasian regional bloc's GDP and 84% of its population. Kazakhstan is second in line, with 8% of GDP and 10% of population, while Belarus and country's economy and population both amount to approximately 5% of the total. According to World Bank's country overview[7], during 2001-2008, Belarus' GDP grew annually by 8,3 %, which was larger growth than that in Europe and Central Asia

[6]http://atlas.media.mit.edu/profile/country/blr/

[7]http://www.worldbank.org/en/country/belarus/overview

**Figure 2:** Products exported by Belarus in 2012 (in %)

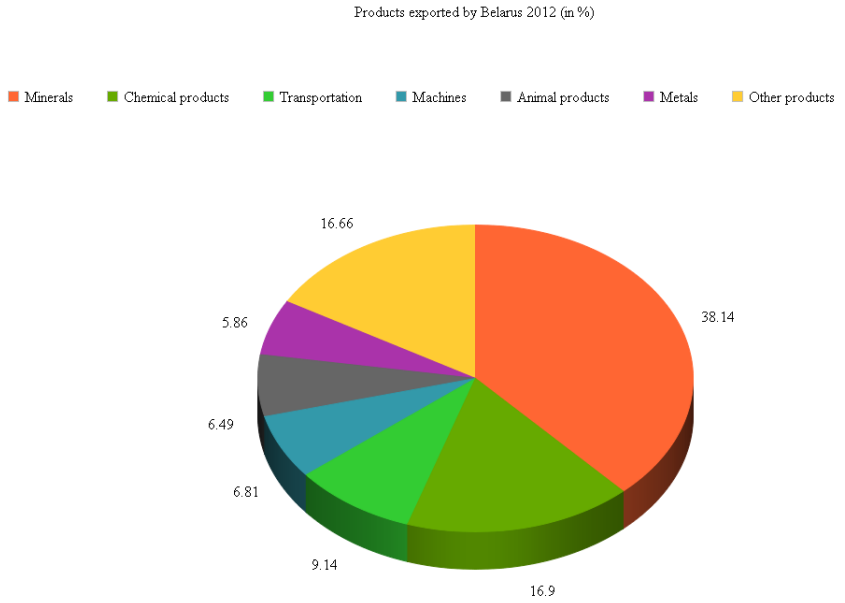



**Figure 3:** Products imported by Belarus in 2012 (in %)

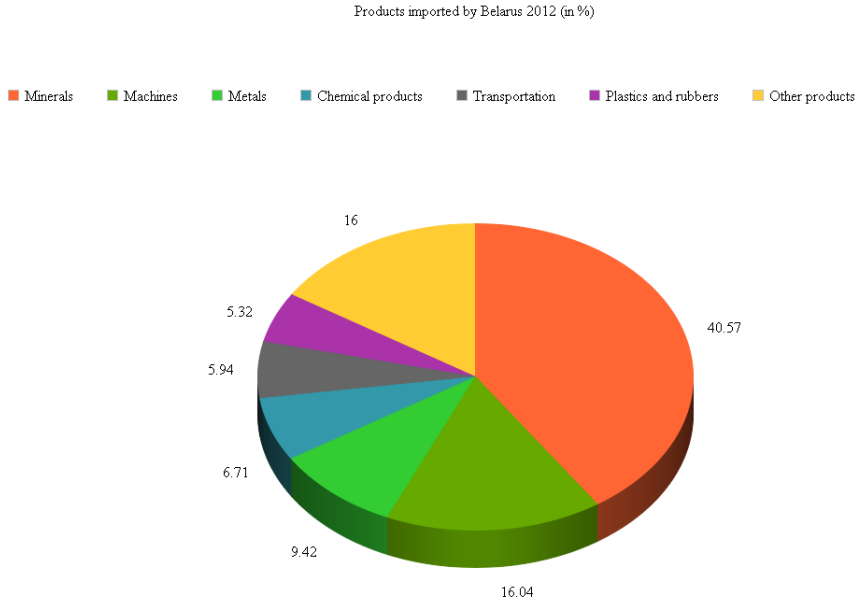
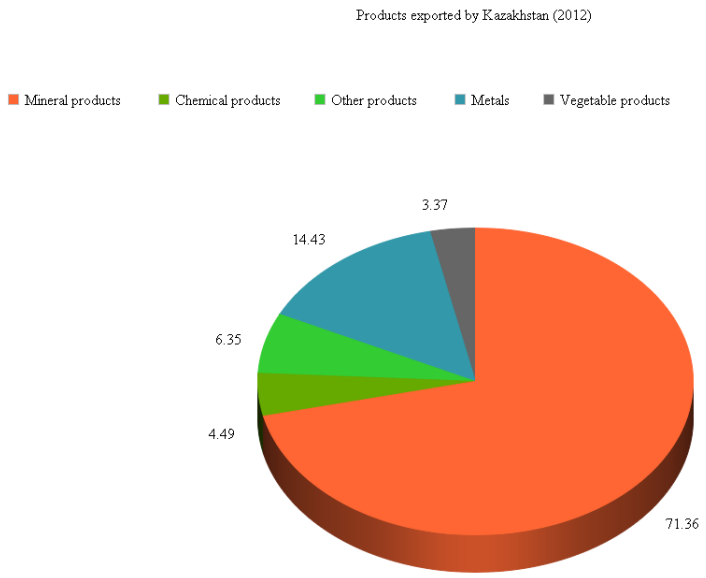


**Figure 4:** Products exported by Kazakhstan in 2012 (in %)



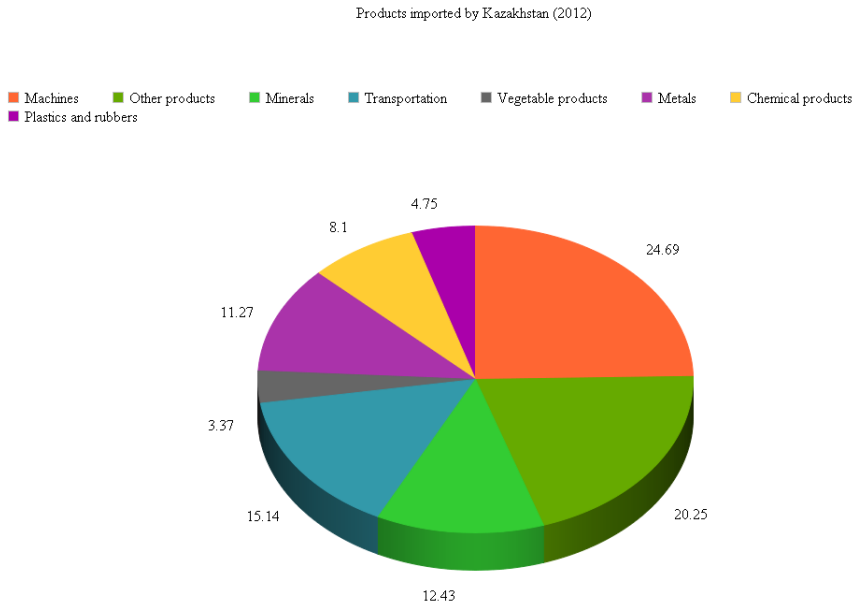

and any other country in the Commonwealth of Independent States. This was largely due to strong export demand by CIS partner countries and underpriced energy imports from Russia. This growth slowed down substantially under world financial crisis of 2008-2009 and the country has since then gone through a recurring macroeconomic instability.

The economy of Kazakhstan is of special interest. Kazakhstan plays a particular role, and not only in the Central Asian region, but also with regards to the Eurasian regional integration. The country has experienced an economic boost and its GDP has been growing by an average of 5 % for the past couple of years. Much of Kazakhstan's export is highly dependent on shipments of oil and other related products (71.36% of total exports in 2012, see figure 4). Country's main export partners are China and Russia. See also figure 5 for overview of Kazakhstan's total imports as given by Observatory of Economic Complexity for 2012.

Recently the president of Kazakhstan, Nursultan Nazarbayev discussed[8] future prospects of the country and what challenges lie ahead. Considering the cyclical downturn in the

[8]http://www.akorda.kz/ru/page/page_218341_poslanieprezidentarespublikikazakhstannnazarbaeva-narodukazakhstana11noyabrya2014g

**Figure 5:** Products imported by Kazakhstan in 2012 (in %)




global economy, current drop in the oil prices, which is the chief exports of Kazakhstan, deteriorated relationship between Russia and the West and the economic sanctions against Russia - he has proposed and put forward several viable projects for 2015 that will help to boost the economy even further, so that the country remains on its path to becoming one of the 30 most economically developed countries, which is the goal. Kazakhstan has almost same GDP per capita as Russia, as well as low unemployment, a balanced budget, little foreign debt and significant foreign currency reserves. Kazakhstan is the main attraction for foreign direct investment, now more than ever, since the political crisis between Western countries and Russia has intensified. Foreign investors are looking for a more stable and prosperous, both politically and economically, place to invest their money in, and Kazakhstan has been able to supply such conditions. For the past years the country has attracted more foreign direct investment per capita than any other country in the Commonwealth of Independent States. Kazakhstan's dynamic development intensifies the growing competition between the country and its closest partners in EEU - Russia and Belarus. This growing economy in the Central Asia might not be a complimentary asset for Russia, but rather a competitive counterpart in the long run. Unlike Russia, Kazakhstan does not have any geopolitical ambitions and does not spend enormous re-

sources on this cause. Instead the country is actively attracting foreign investments in all economic sectors, developing its agricultural sector, has its economic base on exports of raw material and is developing its large potential as a transit center. Kazakhstan is also drastically improving its national infrastructure now and in the following years. This includes everything from modern highways, ports and ferry services, power lines and a transport hub on the border with China. From before Kazakhstan and China, world's largest importer of oil, have developed the first direct oil pipeline[9] running from Caspian shore to Xinjiang in China, with a current capacity of 14 million tons per year. Also, with facilitation from Russia, Kazakhstan is working on its accession to WTO.

Taking account of all these facts, it is a common agreement that Kazakhstan has potential to become driving force of the Central Asian countries. This is in reference to four other Central Asian countries in the former Soviet bloc (Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan), and their potential for integration within Eurasian Economic Union. These countries have a rather low degree of intra-industry and intra-regional trade, as argued by Libman (2008). Even though these countries are landlocked, there has still been low integration because of significant trade barriers, such as high tariffs and frequent changes in them, explicit exports taxes or highly implicit taxes levied on the imported goods but not on the same goods produced domestically. But, as Libman points out, because of Kazakhstan's recent economic success, the country can become a driving force in creating the necessary conditions for development of regional multinationals and help the neighbouring countries to attract foreign direct investments, as well act as a center of attraction for labor migration.

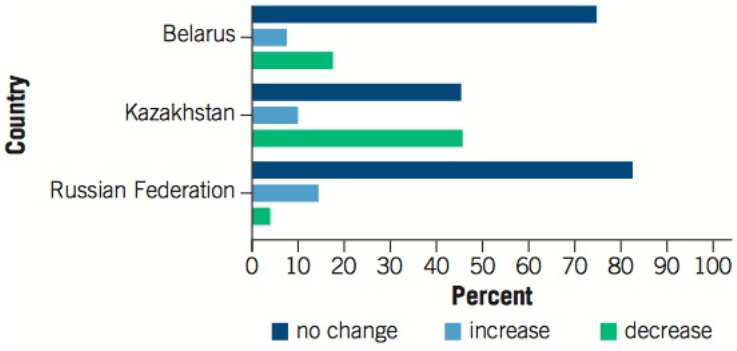
### 2.2.3 Common External Tariff

In its current form, the Customs Union provides a common external tariff within its member states and the removal of their internal customs posts. The common external tariff means that same customs duties, import quotas, preferences or other non-tariff barriers to trade apply to all goods entering the customs union area, regardless of which country within the area they are entering. This way the tariff affects the trade with all non-customs union partners. The common external imports tariff within EEU, adoption of which was the first practical measure to affect the trade of member countries, was able to harmonise more than 85% of tariffs from the outset. In addition to adopting a common

[9]http://en.wikipedia.org/wiki/Kazakhstan?China_oil_pipeline

external tariff, internal border controls between countries were removed. Interestingly, controls were stepped up on the border with direct neighbours in the CIS, which have opted to stay out of the Union (Dreyer & Popescu 2014). As argued by Tarr (2012), the CET is in essence a reflection of the import duties adopted by Russia and because of that big changes have taken place in Kazakhstan, which had to introduce a substantial increase of import tariffs when the country joined the Customs Union. Prior to introducing the common external tariff there already existed a significant level of tariff schedules convergence between Belarus and Russia, and as a result of this Belarus had to increase only 7% of its 11 200 tariff lines, while 18% decreased. On contrary, Kazakhstan increased 10% of its tariff lines, while whole 45% had to be decreased. According to World Bank report (2012) on costs and benefits of the Customs Union for Kazakhstan, the estimated result of implementation of common external tariff increased Kazakhstan's tariffs from an average of 6.7% to 11,1% on an unweighted basis, and from 5.3% to 9.5% on trade-weighted basis. This tariff change made those imports, to which the changes applies, less competitive in comparison with similar goods produced within Customs Union market. In his initial estimation of the Customs Union, De Souza (2011) lists a figure over changes in tariff lines for Belarus, Kazakhstan and Russia (see below) and from it it's clear that Kazakhstan had highest percent of changes. Increases were seen on means of transportation, pharmaceuticals, wood, electro-mechanical domestic appliances, footwear, etc (De Souza 2011).

**Figure 1. Changes in Tariff Lines for Belarus, Kazakhstan, and the Russian Federation**




*Source:* EurAsEC Secretariat.

In Russia, 14% of the tariffs increased and 4% decreased. For Russia, the Customs Union represent an expansion of the market - before the CET many of Russian manufacturing firms were not competitive in Kazakhstan because of low tariffs in Kazakhstan. But these

firms were able to expand their sales to Kazakhstan market once the common external tariff was implemented and Kazakhstan had to increase its tariff on many items. The World Bank (2012) evaluated changes in tariff of the Customs Union as a loss of real income for Kazakhstan, as country's imports were displaced from Europe and under the umbrella of CET most of imports were shifted to Russia, which again represented a substantial transfer of income from Kazakhstan to Russia.

Russia, on the contrary, has less to lose in pure trade terms. The country's largest trading partner is the European Union and since it's imports from Customs Union partners are marginal, the scope of potential trade diversion is less than for Kazakhstan and Belarus. Furthermore, Russia has not had any substantial change in its external tariffs. According to Tarr (2012) the country has benefited by expanding its exports, even if they are not competitive, while Kazakhstan and Belarus were deprived from importing higher quality goods from Europe because of the tariff.

### 2.2.4 Theory of economic integration applied to Eurasian Economic Union

As Eurasian Economic Union is not yet in force, I discuss the patterns of the project as of a Customs Union, without considering the details of the union, such as free flow of labour or capital, or the unification of the economic politics. These specifications are not important for my estimations and hence I omit the discussion of them. What is important is the understanding of theory of economic integration and what the underlying factors and outcomes are. In this section I briefly elaborate on that.

The last 10-20 years are characterized by an extraordinary surge of interest in regional integration. Regionalism has become a dominant factor in the development of world trade, it affects both the economic and political relations between the countries involved, forcing them to decide whether or not to enter trading blocs, which form of integration to prefer, etc. Modern approaches to the study of regional integration are based on the construction of models that assess changes in commodity prices, the trade volume and structure of production in different sectors, gains and losses of the producers, consumers and the state as a result of the mutual elimination of customs duties and general administration of customs barriers.

Formation of the theory of economic integration is associated with works by Viner (1950)

*"The Customs Union Issue"* and Lipsey (1957) *"The Theory of Customs Union: Trade Diversion and Welfare"*, who assessed the impact of entry into regional trade agreements (RTAs) in terms of static effects of trade creation and trade diversion, showing whether or not countries welfare increases or decreases as a result of agreement on customs union that eliminates tariffs in mutual trade. The importance lies in understanding whether the increase in trade attributable to the customs union is due to the emergence of new trade flows, which becomes possible because of liberalization of trade within the customs union (*trade creation*), or due to redirection of existing trade flows from countries outside of the customs union towards customs union countries (*trade diversion*). Trade barriers removal increases the gains from trade if imports from partner country replace less efficient (with higher costs) domestic suppliers, which result in trade creation effect. In contrast, trade diversion occurs when lower cost imports from outside of customs union (free trade zone) are displaced due to the distorting influence of tariff rates on production of partner countries.

In later research regarding the effects of trade agreements on countries net welfare, increasing emphasis was placed on geographic proximity as a criterion for membership in a preferential trade agreement. Regionalism in preferential trade has been argued by some as being key to generating better economic outcomes. Krugman (1991) proposed an idea that if the countries of the regional trading bloc are the so-called "natural partners", they are most likely to benefit from participation in this agreement and the gains will be greater the higher the share of intra-regional trade. In another paper, *"Is Bilateralism Bad?"*, Krugman (1989) expressed worries regarding the trade liberalization and increases of trade blocs and discussed the possibility that countries, that join trading blocs, are more protectionist toward countries outside the blocs than they were before, so that the world trade is actually hurt by such integration in the long run. This is probably best seen with reference to external tariff on imports that members in a bloc have to agree on - if it is given, then there are higher possibilities that it might actually be harmful to the members, while members can benefit if the common external tariff is adjusted optimally. But this is not always the case; in example of Customs Union the external tariff is largely given by Russia with member countries forced to adjust their tariff to it, with subsequent losses. This way a customs union will choose policies that in fact lead to trade diversion. The theory says that the usual increase in relative prices of goods imported from other, non customs union countries, due to higher common external tariff, lead to opposing effects on income. There is real income increase because imports cost relatively less on the world

market, so that the purchase of consumption goods is higher. However, the increase in the domestic relative price of imports reduces consumption and real income because the domestic relative price of imports exceeds the world price. The final effect is the sum of these two, and it can be either positive or negative. In the context of his model, Krugman reflects around the issue of whether or not bilateralism is actually bad or not and concludes that it depends on transportation costs and behavior of the blocs and how they set their tariff policies. He emphasises that it would be rather naive to think that any movement towards freer trade in terms of different trade agreements would exclusively be a positive thing, and that the picture as whole is much more complicated than that. This is true in reference with any other trade theory that different liberalizing projects can be both trade creating or trade diverting, thus having different effects on welfare and economy as such.

Michalopoulos & Tarr (1997) discuss in their paper *"The Economics of Customs Union in the Commonwealth of Independent States"* the partial equilibrium models and how they can be used to consider the static effects of participation in the Customs Union by countries of Commonwealth of Independent States. Their distinction between customs union effects regard static effects and dynamic effects. The static effects, as pointed out, relates to custom union's impact on welfare of participating countries. The dynamic effects focuses on the impact the customs union has on the growth output rate of a country. They draw attention to the fact that output growth can not be equated to welfare growth, as some of the mechanisms that may result in growth of output in the future may at the same time be forces reducing consumption and welfare in the present. They argue on the case of CIS countries joining the Customs Union after the fall of Soviet Union and conclude that the dynamic effects of the customs union are likely to be negative because it will most probably lock countries in the old technology of the Soviet Union. They propose a partial equilibrium model to evaluate the consequences of joining a customs union and adopting a common external tariff, where the CET is higher than the initial tariff. In their paper they exemplify it by saying that adaptation of CET leading to higher import tariffs would be the case for smaller economies, such as Kyrgyz Republic or Armenia, but in the existing Eurasian regional integration today it is the case of Kazakhstan, that had to increase its tariff rate in order to unify under common external tariff. Their conclusion is that a tariff will induce inefficiency losses, and that preferential trade arrangements with small partner countries are inefficient. In later studies, once the Customs Union and the common external tariff between Russia, Belarus and Kazakhstan were in place,

Tarr (2012) sees the parallel to the earlier Customs Union from 1996 that failed due to imposition of large costs on Central Asian countries, who had to buy either lower quality or higher priced Russian manufactured goods under the tariff umbrella. Russian tariff is yet again the point of departure for the present Customs Union but still it has a potential to succeed. According to Tarr, due to Russia's accession to the WTO in 2012, the tariff of the Customs Union will fall by 40-50 percent. This, together with Customs Union's aim to reduce non-tariff barriers and more deeper integration (i.e. service liberalization, free flow of capital and labour and some regulatory harmonization), has a greater potential for a successful economic union between post-Soviet countries.

There are still justifiable concerns that the institutional development of these countries are not progressed far enough to take full advantage of greater integration. As it is reported by Heritage Foundation Index of Economic Freedom the various CIS countries have varying levels of trade freedom that is liberalizing only slowly, if at all. Heavy country interventions means that trade is still directed, rather than liberalized, thus distorting both its composition and its direction. Hartwell (2013) argues that the proposed moves toward increased integration can raise welfare of member states if they fulfil the "second-best" alternative and allow for greater policy and institutional liberalization. The theory of second best was formalized by Lipsey & Lancaster (1956) in *"The General Theory of Second Best"*, when they showed that if one Pareto optimality condition in an economic model cannot be satisfied, then all other Pareto conditions are no longer desirable and an optimum situation can be achieved only by departing from all the other Pareto conditions. The optimum situation then attained is to be perceived as second best, because it is achieved subject to a constraint, which prevents the attainment of a Pareto optimum. When applied to international trade theory the theorem indicated that trade policies introduced in a customs union can improve national welfare in the way that they act to correct the imperfections or distortions. This increase in national welfare is larger that the loss in welfare arising from the application of the policy.

But theory is not always applicable. Heritage Foundation Index of Economic Freedom[10] gives a pretty fair overview of different economic freedoms in all three countries within Eurasian regional integration, ranging from investment and trade freedoms, to corruption and business freedoms. When it comes to trade freedom the level of it has been below the world average for both Belarus and Russia in 2009, while for Kazakhstan it was above the average. During the following years this level increased for Russia and Belarus and

[10]http://www.heritage.org/index/visualize

today all three countries are approximately on the same level of trade freedom, with Belarus scoring higher than the initial trade liberalization by Kazakhstan, a score of 81,4. This ideological bias towards controlled trade has its roots in the development of the financial sectors of Russia, Belarus and Kazakhstan. A lack of liberalization of financial systems pervades the region. Also, according to the World Bank's Ease of Doing Business rankings[11], no country in the CIS is even in the top 100 in terms of "ease of trading across borders" [12]. This clearly points out the large existence of non-tariff barriers between the member countries. From a political standpoint many trade and integration barriers remain in place because there are vested in interests in keeping these barriers, and unilateral liberalization is practically impossible. This distorts production and trade, creating rent-seeking opportunities.

Most of the independent researches conducted regarding the prospects of the Eurasian regional integration conclude with the notion that this kind of greater integration has a potential to work and be successful for all parties only if it is based on fostering the trade liberalization that has been missing from the region. Acting as the European Union did back in the post-war era, the Eurasian Union could help member countries take the liberalizing steps they could not take on their own.

Accession of Kazakhstan and Belarus to WTO, elimination of non-tariff barriers to trade between member countries and closer cooperation between EU and EEU could be some of the driving forces for success of Eurasian Economic Union. A cooperation with EU could help EEU to bring about the benefits that the EU has conferred on Europe, including creating political stability, internal economic liberalization and continued engagement with its periphery (Hartwell 2013). The European Union is associated with modernization and rule-based governance, and in this way a closer cooperation between these two regional unions can promote Russia to adopt similar approach for its regional policy and the other members of EEU will follow. Even though the current diplomatic crisis because of situation in Ukraine makes the environment somewhat aggressive, looking purely objectively at the economic aspects there is a solid foundation for some sort of economic cooperation between EU and countries of EEU. The territorial proximity, large investment potentials, even larger trade flows coupled with transfer of technologies are some of the factors as to why an economic integration would be a good idea for both parts.

[11] http://data.worldbank.org/indicator/IC.BUS.EASE.XQ
[12] http://www.doingbusiness.org/data/exploretopics/trading-across-borders

# 3 The Gravity Model of International Trade

In this chapter I introduce and discuss the gravity model of international trade, which is commonly used to measure effects of economic integration agreements (EIAs) on trade flows. I start by reviewing brief history of gravity in trade and it is not my intend to present a deep understanding of the model, as it is large and complex. I present a selected survey where I focus on what is most relevant for my thesis, the tools needed to discuss the effects of economic integrations agreements on trade flows. In later chapters I apply these tools to my estimation of effects of Eurasian regional integration on bilateral trade flows of the given countries in my data.

First, I introduce the basic version of the gravity model which is fundamental for understanding the modern concept of gravity equation in trade. Then I present a theoretical gravity equation as proposed by Anderson & Wincoop (2003) which has been groundbreaking in theory of international trade, with its strength and limitations. Here I also review in short alternative specifications of the theoretical gravity model. Following the theoretical approach I discuss the most common estimation methods used in the gravity literature. The discussions are limited to what is relevant for my estimation in chapter 4.

## 3.1 Brief history of gravity in trade

In recent decades there has been a continued globalization of economic processes, and there is continuously growing volume of international trade. Creation of General Agreement on Tariffs and Trade (GATT), then later World Trade Organisation (WTO), various forms of preferential trade agreements, establishment of international institutions to facilitate and promote trade in one way or another reduce the total costs of production of the world´s output and increase the diversity of commodities. A global production model becomes all the more familiar, in which various intermediate components are produced in different countries on different continents, while many large manufacturing firms have long become transnational. Over the past twenty years world trade has significantly changed the locations of production facilities. Virtually all countries, with only few exceptions, are intensively involved in international trade. The recent economic crisis of 2008-2009 showed that such model of global economy, even if it implies greater diversification of trade relations, still led to transfer of risk via a commodity chain to basically all world economies once the problems were detected with key economic players. In situations like these, in order to hold on to a sustainable economic policy, it is crucial to understand the

mechanisms and limitations of international trade, and also factors that affect the volume and routing (selection of specific delivery schemes) of trade flows. One of the most popular econometric models, which can be obtained from many of the classical trade theories that attempt to identify the given factors, is the gravity model of international trade. I don't think there has been a single article on application of gravity equation that has not used term "empirical workhorse" when explaining the equation´s ability to study *expost* effects of different trade agreements on bilateral trade flows.

Nobel laureate Tinbergen (1962) was the one to introduce the gravity model when he, in 1962, published an econometric study using the gravity equation for international trade flows. He brought the Newtonian law of universal gravitation into the theory, stipulating that trade between two countries is proportional to the product of the countries size (in gross domestic product) and inversely proportional to the distance between them. Loosely speaking this means that the bilateral trade increases as the economic size of countries increases, and decreases as the distance between the trading countries increases. As the author noted himself, the application of the model is quite simple, as it connects the volume of export from one country to another, $X_{ij}$, with the following explanatory variables: GDP of the exporting country $Y_i$ (or just a function of the exporting country´s characteristics), GDP of the importing country $Y_j$ (function of importing country´s characteristics), geographical distance between these two countries, $\Phi_{ij}$, and a log-normally distributed error term $\epsilon_{ij}$:

$$X_{ij} = Y_i Y_j \Phi_{ij} \epsilon_{ij} \tag{3.1.1}$$

Tinbergen did not use any theoretical predictions and applied the econometric model specifications right away. He explained the choice of the above given explanatory variables by following intuitive considerations:

1. the volume of export of goods that a country can provide for international exchange depends on the size of the country´s economy (i.e. GDP);

2. the quantity of goods that can be sold in any country depends on the size of the country´s market (i.e. GDP);

3. the trade volume should depend on goods transportation costs, which, by author´s assumptions, should be proportional to the distance between countries considered.

In addition, Tinbergen added dummy variables in his regression (variables that take on values 1 or 0) for estimation of participation of partner countries in various trade agreements, such as British Commonwealth or the BENELUX Free Trade Agreement, and also a dummy for whether or not two countries share a common land border. The author used simple multiplicative expression that associate the above given factors with export volumes from one country to another. Equation (3.1.1.) can be modelled in a linear form by taking its logs and adding the dummies:

$$lnX_{ij} = ln\beta_0 + \beta_1 lnY_i + \beta_2 lnY_j + \beta_3 ln\Phi_{ij} + \beta_4 ADJ_{ij} + \beta_5 EIA1_{ij} + \beta_6 EIA2_{ij} + ln\epsilon_{ij} \quad (3.1.2)$$

where $ln\beta_0$ is a constant term, and $ADJ_{ij}$ is dummy variable for common land border, while $EIA1_{ij}$ and $EIA2_{ij}$ are dummies for various trade agreements.

An empirical estimation of this equation with respect to 42 countries showed that main variable coefficients are significant and had correct sign, consistent with intuitive predictions of the model. These results lay ground for further widespread use and replication of this form of the gravity equation. At the same time, the work of Tinbergen did not provide a strict and comprehensive theoretical basis of this specification of the trade equation. The traditional approach of linearizing and estimating the gravity equation using OLS techniques was not efficient enough.

The model is mostly used in relation to examination of bilateral trade patterns in search of evidence on regional trading blocs, the estimation of trade creation and trade diversion effects from regional integration (Frankel & Romer (1999), Brada & Mendez (1985)); the estimation of trade potential, for instance with application to trade between the European Union and its potential members (Baldwin (1994), Hamilton & Winters (1992)). The model was widely used and applied in 1990s when numerous authors employed it to assess the potential benefits of trade between the European Union and newly (due to fall of Soviet Union) transforming economies of Central and Eastern Europe.

### 3.1.1 Limitations of the basic gravity equation

The traditional gravity equation gained large acceptance among trade economists and international policymakers for at least three reasons:

1. Formal theoretical economic foundations surfaced for a specification similar to the traditional gravity equation. In his article *"A Theoretical Foundation for the Gravity Equation"* Anderson (1979) showed that a simple general equilibrium model with products differentiated by country of origin and constant elasticity of substitution preferences yields a basic gravity equation; *"Market Structure and Foreign Trade"* by Helpman & Krugman (1985) introduced assumptions of monopolistic competition and increasing returns to scale, thus explaining intra-industry trade with gravity equation between countries with similar factor endowments and labor productivities; *"The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence"* by Bergstrand (1985) introduced proxies for multilateral price terms for importers and exporters, showing empirically their importance in explaining bilateral trade flows between countries;

2. Consistently strong explanatory variable (high R2 values);

3. Policy relevance for analyzing the multitude of free trade agreements over the past 15 years.

But, the traditional theoretical gravity model specification has in later years come under scrutiny and large criticism. The reasons are many:

- The traditional specification ignores the fact that the "remoteness" of regions $i$ and $j$ from the rest-of-the-world's ($ROW's$) regions should influence the volume of trade from $i$ to $j$, and the economic size of the $ROW's$ regions matters as well. This is intuitive: suppose countries $i$ and $k$ enter into a preferential trade agreement that lowers tariffs of their respective goods. Basic economic theory will suggest that this will most probably have an effect on trade flows of country $j$, even though it is not part of the agreement. Trade creations and trade diversions are examples of such effects. However, the traditional gravity model does not account for this effect at all. This is at odds with standard trade theory and is a classical case of omitted variable bias.

- Applications of the traditional gravity equations to study the bilateral trade costs often yielded seemingly implausible findings. This can be seen from McCallum´s result of *"border puzzle"* (*"National Borders Matter: Canada-U.S. Regional Trade Patterns"* McCallum (1995)), when the estimates of the effects of national borders on intra-continental (world) and inter-regional trade flows are often implausibly

high. On the example of United States and Canada border, McCallum showed that inter-province trade in Canada is 22 (2200%) times larger than the country's trade with the US states, all else equal, a result called home bias effect in trade theory. This result indicates that the presence of formal and informal trade barriers following national borders is the reason as to why inter-regional trade increases and home bias exists. Anderson & Wincoop (2003) apply their theoretical gravity model to resolve this border puzzle, and conclude that McCallum's large border parameter for Canada happened due to a combination of the relative small size of the Canadian economy (which was not taken into account) and omitted variable bias (multilateral resistance terms are not included in the estimation). Once controlled for these two factors, Anderson and van Wincoop conclude that the national borders reduce trade between the US and Canada by about 44%, thus solving the border puzzle. Anderson and van Wincoop paper was framed as a resolution to the puzzle McCallum had exposed.

The introduction of multilateral resistance to trade by Anderson and van Wincoop and the subsequent inclusion of heterogeneous productivity on the supply side showed how the gravity model had capacity to go from being an empirical relation to a model with full theoretical foundation, applicable in the modern theory of international trade. In the next section I go into detailed microfoundations of the basic model and of the Anderson and van Wincoop model. I focus on limitations of the model and look briefly at alternative specifications, considered on the demand side and the supply side. Further I focus my attention on econometric estimation of the theoretical gravity model and look at alternative to Anderson and van Wincoop methods.

## 3.2 Microfoundations

### 3.2.1 The general definition

The general version of the gravity equation implies that now all characteristics of exporter/importer are included in the definition variables, in contrast to model by Tinbergen, where characteristics were specified to gross domestic product (GDP) of both exporter and importer. I follow the basic form of the gravity equation by Head & Mayer (2014), given as:

$$X_{ij} = GS_i M_j \phi_{ij} \epsilon_{ij} \tag{3.2.1}$$

Here $X_{ij}$ is the same variable of bilateral export from country $i$ to country $j$, as before. $S_i$ represents all "capabilities" of the exporter $i$, $M_j$ captures all characteristics of the importer market $j$, $\phi_{ij}$ represents bilateral accessibility of exporter $i$ to importer $j$ and combines all concepts of frictions in trade (all from natural trade costs, such as geographical distance, to politically motivated trade costs, such as borders, tariffs and NTBs). Lastly, $G$ is a gravitational constant, which is allowed to vary over time if the above equation was estimated using panel data analysis.

The most important feature of this equation, as argued by Head & Mayer (2014), is that this way of defining the gravity equation requires that third-country effects must come through the multilateral terms $S_i$ and $M_j$. By imposing a small set of additional conditions, Head and Mayer express the exporter and importer terms in equation (3.2.1), $S_i$ and $M_j$ as functions of observables:

$$X_{ij} = \frac{Y_i}{\Omega_i} \frac{X_j}{\Phi_j} \phi_{ij} \epsilon_{ij} \tag{3.2.2}$$

where $S_i = \frac{Y_i}{\Omega_i}$ and $M_j = \frac{X_j}{\Phi_j}$. Equation (3.2.2) is called the *structural gravity equation.* Country $i's$ value of production, $Y_i = \Sigma_j X_{ij}$ is defined as the sum of its exports to all regions, and the value of country $j's$ expenditure, $X_j = \Sigma_i X_{ij}$, is defined as the sum of its imports across all exporters. The terms $\Omega_i$ and $\Phi_j$ are the multilateral resistance terms defined as:

$$\Phi_j = \sum_l \frac{\phi_{jl} Y_l}{\Omega_l} \qquad and \qquad \Omega_l = \sum_l \frac{\phi_{lj} X_l}{\Phi_l} \tag{3.2.3}$$

What is important with these two multilateral resistance terms is that they include all trade frictions between all trading partners for both $i$ and $j$, i.e. partners $l$. The friction between $j$ and its other trading partners, all $l \neq i$, will affect its demand for goods from $i$.

This basic form for the gravity equation relates bilateral exports multiplicatively to the exporter´s value of production, importer´s value of expenditure, the bilateral trade frictions

and controls for multilateral resistance. The fact that each term enters multiplicatively does not necessarily reflect any features of economic theory, and is rather rooted in the model because of its historical analogy to the Newtonian law of gravity. However, beyond this point of specification of the multilateral resistance terms, this type of gravity model is difficult to use for estimation purposes, and hence a more elaborate theoretical framework is needed. In the next section, I derive the general framework from Anderson & Wincoop (2003), omitting some of the calculations (or rather leaving them for appendix), discuss briefly limitations of their equation and some of the alternative approaches. Then I go further into alternative estimation methods of the equation and its estimation given by Feenstra (2004) (fixed effects OLS estimation), Baier & Bergstrand (2009) (first order Taylor approximation of the multilateral resistance terms) and Silva & Tenreyro (2006) (Poisson Pseudo Maximum Likelihood estimation).

## 3.3 Anderson and van Wincoop gravity model

Common to most of the theoretical papers on gravity equations before Anderson and van Wincoop´s introduction of multilateral resistance to trade was the role of price levels. Anderson & Wincoop (2003) refined the theoretical foundation of the gravity models to properly account for the endogeneity of trade costs and the consideration of institutional barriers to trade. Based on the theoretical model of trade they indicated that costs of bilateral trade between two regions are affected by the average trade costs of each region with the rest of its trading partners and provided evidence of border effects in trade, using a Non-linear least squares estimation (NLS). In this they introduced notion of multilateral resistance, which is the average barrier between two partners to trade with others (Kepaptsoglou, Karlaftis & Tsamboulas 2010).

### 3.3.1 Deriving the theoretical gravity equation

One of the main underlying assumptions in the Anderson and van Wincoop model (A-vW model) is that consumers have identical and homothetic preferences and hence their utility exhibit Dixit-Stiglitz constant elasticity of substitution (CES). The second important assumption of the A-vW model is that goods are differentiated by place of origin. This so-called Armington assumption, after Armington (1969), implies that two goods of the same type originated from different regions are imperfect substitutes. A related assumption is that each country specializes in production of only one good and regards the supply of

each good as fixed.

The CES utility function is stated as:

$$U_j = \left[ \sum_{i=1}^{N} \beta_i^{(1-\sigma)/\sigma} c_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \tag{3.3.1}$$

where $c_{ij}$ is consumption of goods from $i$ by consumers in $j$, $\sigma$ is the elasticity of substitution, $\beta_i$ is an arbitrary parameter of preference towards goods from country $i$ and $N$ is the number of countries.

The consumers maximise their utility subject to the budget constraint:

$$\sum_{i=1}^{N} p_{ij} c_{ij} = Y_j \tag{3.3.2}$$

where $p_{ij}$ is the price on goods faced by importers in country $j$ (exporter $i$´s supply price) and $Y_j$ is the nominal income of the region $j$´s residents. Prices on the goods differ between locations due to trade costs that are not directly observable and it has been the main objective of the empirical work to identify exactly these costs. Trade costs are modelled according to "iceberg"-structure, where it is assumed that a fraction of costs $t_{ij}$ of the good is lost (i.e. it "melts", hence "iceberg" definition). Taking this into account the price of goods from $i$ sold in $j$ can be written as $p_{ij} = p_i \tau_{ij}$, where $p_i$ is the exporter´s supply price and $\tau_{ij} = 1 + t_{ij}$ are trade costs that incurs imports. The nominal value of exports from $i$ to $j$ is then $X_{ij} = p_{ij} c_{ij} = \tau_{ij} p_i c_{ij}$. Total income of region $i$ is therefore $Y_i = \sum_j X_{ij}$, that can also be thought of as a market clearing condition.

Maximazation of (3.3.1) subject to the budget constraint in (3.3.2) with respect to $c_{ij}$ yields following demand function (for full derivation see appendix A):

$$X_{ij} = \left( \frac{\beta_i p_i \tau_{ij}}{P_j} \right)^{1-\sigma} Y_j \tag{3.3.3}$$

where $P_j$ is the consumer price index of country $j$, given by:

$$P_j = \left[ \sum_i (\beta_i p_i \tau_{ij})^{1-\sigma} \right]^{1/(1-\sigma)} \tag{3.3.4}$$

Anderson and van Wincoop apply the same technique in deriving their gravity equation as one by Deardorff (1998), who followed Anderson (1979) in using equation for market clearance to solve for the coefficients ($\beta_i$), while imposing the choice of units such that supply prices $p_i$ are equal to one and then substituting into the import demand equation. The only difference from this approach that Anderson and van Wincoop take is that this time they are interested in the general equilibrium determination of prices and in comparative statistics where these will change, and hence they keep the price variable, insert $X_{ij}$ from equation (3.3.3) into the market clearing condition $Y_i = \sum_{j=1}^{N} X_{ij}$ and solve for $(\beta_i p_i)^{1-\sigma}$, yielding:

$$(\beta_i p_i)^{1-\sigma} = \frac{Y_i}{\sum_{j=1}^{N} (\frac{\tau_{ij}}{P_j})^{1-\sigma} Y_j} \tag{3.3.5}$$

Now define world GDP as $Y^w = \sum_{j=1}^{N} Y_j$. Expanding the right hand side of equation (3.3.5) by $(\frac{1}{Y^w})(\frac{1}{Y^w})^{-1}$ , and inserting the following from this expression back into the demand equation in (3.3.3) yields:

$$X_{ij} = \left(\frac{\tau_{ij}}{P_j}\right)^{1-\sigma} \frac{Y_j Y_i}{Y_w} \left[\sum_{j=1}^{N} \left(\frac{\tau_{ij}}{P_j}\right)^{1-\sigma} \frac{Y_j}{Y^w}\right]^{-1} \tag{3.3.6}$$

Rearranging this equation yields the Anderson and van Wincoop gravity model:

$$X_{ij} = \frac{Y_j Y_i}{Y_w} \left(\frac{\tau_{ij}}{P_i P_j}\right)^{1-\sigma} \tag{3.3.7}$$

where $P_i^{1-\sigma}$ and $P_j^{1-\sigma}$ are *the multilateral resistance terms*, defined as:

$$P_i^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{\tau_{ij}}{P_j}\right)^{1-\sigma} \frac{Y_j}{Y^w} \tag{3.3.8}$$

$$P_j^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{\tau_{ij}}{P_i}\right)^{1-\sigma} \frac{Y_i}{Y^w} \tag{3.3.9}$$

Multilateral resistance terms in their simplest definition means that if two countries are surrounded by two larger economies, say Belgium and Netherlands bordered with France

and Germany respectively, then they will trade less between themselves than if they were surrounded by oceans (like Australia and New Zealand), or by vast stretches of deserts and mountains (such as Kyrgyzstan and Kazakhstan). These terms capture the fact of dependence on trade costs across all possible exports markets (for the exporters) and all suppliers (for the importers). Furthermore, specific to their estimation, Anderson and van Wincoop define the unobservable trade costs $\tau_{ij}$ as a log linear function of observables - bilateral distance between countries $i$ and $j$, $d_{ij}$, and whether there is an international border between $i$ and $j$, a dummy variable $b_{ij}$:

$$\tau_{ij} = d_{ij}^{\rho} e^{b_{ij}} \tag{3.3.10}$$

### 3.3.2 Limitations of the Anderson and van Wincoop model

Anderson and van Wincoop developed a theoretical solution to the multilateral resistance problem, that played a pivotal role of their impact on the theory of gravity equation, but had trouble in their estimation of this theoretical approach. The multilateral resistance terms $P_i$ and $P_j$ are not observable since they do not correspond to any price indices collected by national statistical agencies. To be able to solve the model in terms of observed data, Anderson and van Wincoop make additional assumptions. One of the assumptions is that country j´s expenditure, $X_j = \sum_i X_{ij}$ is equal to its nominal income $Y_j$, $X_j = Y_j$. They also assume symmetric trade costs $\tau_{ij} = \tau_{ji}$, which in principal is a very strong assumption, because most of bilateral trade costs are asymmetric. In their theoretical approach the elasticity of substitution $\sigma$ is also unobservable, so they end by by *assuming* values of $\sigma$. Together these assumptions imply symmetric price indices, $P_i = P_j$. As an estimation method Anderson and van Wincoop propose the nonlinear least squares estimation (NLS).

One of the biggest problems with these assumptions and the underlying estimation method is that the assumption of symmetric trade costs is very strong, and the nonlinear least squares estimation method is very difficult, and time and data consuming. Hence there has been a need for an alternative estimation method and another way of proxying for multilateral resistance terms. A simpler alternative, often used, is to use a proxy for multilateral resistance terms called "remoteness" variable Herrera & Baleix (2010) ( *"Are*

*estimation techniques neutral to estimate gravity equations? An application to the impact of EMU on third countries' exports"*):

$$Rem_i = \Sigma_j \frac{dist_{ij}}{(GDP_j/GDP_{ROW})} \tag{3.3.11}$$

where the numerator is the bilateral distance among two countries, $i$ and $j$, and the denominator is the share between each country´s GDP in the rest of the world´s ($ROW$) GDP. Anderson and van Wincoop include this variable in their regression and compare their previous results with estimation results with remoteness variable, and conclude that this procedure is not theoretically correct, since the only trade barrier the variable captures is distance. Which is not the only bilateral barrier to trade between countries.

If we go back to our structural gravity equation in (3.2.2), the assumptions by Anderson and van Wincoop of balanced trade ($X_i = Y_i$) and symmetric trade costs ($\phi_{ij} = \phi_{ji}$) will yield $\Phi_i = \Omega_i$. This will in turn imply $S_i = M_i$ in the general equation, leading to a symmetric gravity equation. In the next subsection I go further into alternative theoretical specifications of the gravity equation, albeit not detailed.

### 3.3.3 Alternative specifications of the gravity equation

The historical approach to proxy for multilateral resistance with remoteness terms appeared too weak once the theoretical modelling of gravity became clearer, as predicted by Anderson and van Wincoop. And since their own approach and estimation method appear to meet criticism, several alternative methods have been proposed. Head & Mayer (2014) go through a range of variants of gravity for trade that comply with the structural gravity assumptions. Without going into detailed mathematical specifications, I review here in short something that has been defined as the demand side specifications and the supply side specifications of the theoretical gravity model. After that I go over to econometric estimation of the gravity model in section (3.4).

*Demand side specifications*

As mentioned previously, the first economic foundation for the gravity model was based on specifying the expenditure function to be a constant elasticity of substitution (CES) function (Anderson 1979). This is the same used in theoretical model's specification by Anderson & Wincoop (2003). Trade under monopolistic competition and the gravity

equation are often linked with each other. The gravity equation arises naturally whenever countries are specialised in different goods. Such specialisation is sometimes called the "national product differentiation" and this occurs under the monopolistic competition model. The standard symmetric Dixit-Stiglitz-Krugman monopolistic competition assumption states that each country has $N_i$ firms supplying one unique variety each to the world from a home country production site. The monopolistic competition implies increasing returns to scale. Consumers follow the same CES utility structure as in the Anderson and van Wincoop model with assumption of "love of variety" preferences. Bergstrand, Egger & Larch (2013) use this alternative approach in their research. In their model the "love of variety" assumption implies that the exogenous preference parameter $\beta_i^{1-\sigma/\sigma}$ in the CES utility function (3.3.1) is now replaced by endogenous number of preferred varieties (number of firms) by the consumer, $n_i$. Assuming same prices and trade costs as before, the utility maximisation is as follows:

$$U_j = \left[ \sum_{i=1}^{N} n_i c_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \tag{3.3.12}$$

subject to

$$Y_j = \sum_{i=1}^{N} n_i p_i \tau_{ij} c_{ij} \tag{3.3.13}$$

Which yields following demand for each variety (I omit the derivation):

$$c_{ij} = \frac{(p_j \tau_{ij})^{-\sigma}}{P_j^{1-\sigma}} Y_j \tag{3.3.14}$$

On the production side, labor is the only resource and each firm requires the following labor to produce output of $y_i$:

$$l_i = \alpha + \varphi y_i \tag{3.3.15}$$

where $\alpha$ is the fixed labor input (cost) needed for production and $\varphi$ is the marginal labor input. Monopolistic competition has two key equilibrium conditions for the firms. First

is that each firm maximises its own profits, which ensures that prices are a markup over marginal costs:

$$p_i = \frac{\sigma}{\sigma - 1}\varphi w_i \tag{3.3.16}$$

where $w_i$ is the wage rate in country $i$ and $\varphi w_i$ determines the marginal cost of production. Second, there is free entry to firms whenever economic profits are positive, so the long-run equilibrium must ensure zero profits, yielding that:

$$y_i = \frac{\alpha}{\varphi}(\sigma - 1) = y \tag{3.3.17}$$

so that the output in each firm in each country is the same, $y_i = y$. Then, to determine the equilibrium number of products/firms they make use of the assumption of full employment of labor in the economy, using equation (3.3.15):

$$n_i l_i \Rightarrow n_i(\alpha + \varphi y_i) = L_i \Rightarrow n_i = \frac{L_i}{\alpha\sigma} \tag{3.3.18}$$

Following Feenstra (2004), Bergstrand et al. (2013) establish that the value of aggregate bilateral exports from country $i$ to country $j$ is given by $X_{ij} = n_i p_i \tau_{ij} c_{ij}$, where $n_i$ is the number of firms (products) in country $i$, $\tau_{ij} \geq 1$ are ad-valorem iceberg trade costs, and $c_{ij}$ is demand in $j$ for output of each firm in $i$. Inserting the demand function (3.3.14), the equilibrium price (3.3.16) and the equilibrium number of firms in (3.3.18) into this aggregate exports function yields the alternative Bergstrand et al. (2013) gravity equation:

$$X_{ij} = Y_i Y_j \frac{(Y_i/L_i)^{-\sigma}\tau_{ij}^{1-\sigma}}{\sum_{l=1}^{N} Y_l (Y_l/L_l)^{-\sigma}\tau_{lj}^{1-\sigma}}\epsilon_{ij} \tag{3.3.19}$$

where $\epsilon_{ij}$ is the multiplicative error that the bilateral trade flows is measured with. Subject to the market clearing condition $Y_i = \sum_j X_{ij}$ (which is the same as in Anderson and van Wincoop), this represents an alternative structural gravity equation based on a unconditional general equilibrium framework. Bergstrand et al. (2013) note three results from this: that the system of equation (3.3.19) subject to the market clearing condition

allows for asymmetric bilateral trade costs, which was not possible in the model by Anderson and van Wincoop; that all endogenous variables in the model (such as $Y_i$, $X_{ij}$ and $Y_i/L_i$) have observable values for the initial conditions and that $p_i$ (proportional to $w_i$) is identified, which was not possible in the Anderson and van Wincoop model. They establish three alternative methods to correctly estimate elasticity of substitution $\sigma$ and by applying their framework empirically to McCallum's "border-puzzle" generate an unbiased estimate of the elasticity of substitution and economic welfare comparative statics that differ significantly from those provided by Anderson and van Wincoop's technique.

*Supply side specifications*

Eaton & Kortum (2002) derive a mathematically equivalent structural gravity model that is based on homogeneous goods on the demand side, iceberg trade costs and Ricardian assumption of difference in technology with heterogeneous productivity for each country and each good. This assumption of firm heterogeneity makes it possible to analyze how trade costs affect the production structure. In equilibrium of this model the share of goods demanded from country $i$ to country $j$ is determined only on the supply side and the influence of elasticity of substitution $\sigma$ disappears into a constant term. If some frictions in bilateral trade increases marginal cost of production of a good, then trade will be reduced through reduction of the production within each firm, i.e. via the extensive margin. If it happens so that firm's fixed costs are increased, then trade flow will decrease due to the fact that fewer firms will be able to produce. This kind of model was used by Egger & Larch (2011).

## 3.4 Estimating the Gravity Model - Methodology

After the debate on the theoretical specification of the gravity model found some peace with the specification by Anderson and van Wincoop of the multilateral resistance terms and subsequent alternative specifications, it then turned to the important issue of performance of different estimation techniques. There are a number of ways to estimate a gravity model, all dependent on which structural representation is determined and what econometric issues are desirable to estimate. To this day there are three important issues in estimation of the gravity model: how to control for unobservable theoretical multilateral resistance terms econometrically, what to do with zero-observations in trade due to log-linearization of the theoretical model and how to control for the endogeneity of free

trade agreements. Problems concerning the validity of the log-linearization process of the gravity model in the presence of heteroskedasticity of the error terms and the loss of information due to the zero trade flows have been explored more specifically recently.

Zero observation of trade means that not all countries trade with each other, and those observations with zero trade in the dataset will be eliminated, when the equation is log-linearized, and so in this way we omit important information; and the endogeneity of FTA's means that free trade agreements are not a product of two countries deciding upon it, but it is more a product of something that is naturally existent. As said earlier regarding Anderson and van Wincoop gravity model, both use of non-linear least squares in estimation and the assumption of symmetric trade costs have been criticised, when it comes to their theoretical specification of the multilateral resistance terms. To account for these issues I discuss here three sets of alternative techniques that have been applied in the literature: fixed effects OLS estimation, Taylor series approximation of the multilateral resistance terms by Baier & Bergstrand (2009) and Poisson Pseudo Maximum Likelihood estimation by Silva & Tenreyro (2006) as explained by Shepherd (2012) *"The Gravity Model of International Trade"*. But before I start with these I overview briefly the linear method of ordinary least squares estimation.

I also dwell somewhat on the issue of reversed causality in the estimation. The theory is that high income leads in general to more trade, but it is also apparent that more trade leads to higher income. As gravity equation performs poorly in estimating the effects of increase in trade flows on welfare, I rather look on the reverse causality in trading partners-countries initiatives to establish free trade agreement between themselves. As discussed in details by Baier & Bergstrand (2007) and Egger, Larch, Staub & Winkelmann (2011) the free trade agreement variable is not an exogenous independent variable as was assumed previously, but an endogenous one. The reverse causality is reflected in the idea that just as much membership in a FTA increases trade flows for its members, increased trade leads to endogenous determination to create a free trade agreement.

### 3.4.1 Estimation by Ordinary Least Squares

The logical place to start with an econometric estimation of gravity equation is by use of Ordinary Least Squares (OLS) method. The OLS method has been traditionally the usual technique for estimating the coefficients of the gravity model specification in its log linear form, given as:

$$\ln X_{ij} = \ln S_i + \ln M_j + \ln \Phi_{ij} + \ln \epsilon_{ij} \tag{3.4.1}$$

The OLS minimises the sum of squared random disturbances $\epsilon$. Under certain assumptions regarding the error term $\epsilon_{ij}$ (such as normal distribution and uncorrelation with the explanatory variables), OLS yields parameter values that are intuitively appealing and have useful statistical properties. But the assumption of constant error variance across observations (homoskedasticity) is a very strong one, and in the general case the error terms perform on the contrary as heteroskedastic, leaving the regular OLS estimation non-efficient. This is the most important reason as to why the OLS estimation of the gravity equation has come under scrutiny. Additionally, when the gravity equation is log-linearized there is loss of efficiency of the estimation due to the loss of information that lead to biased estimates because of omission of data.

### 3.4.2 Fixed effects OLS estimation

The method most commonly used for controlling the multilateral resistance terms, and which does not require assumption of symmetrical trade costs, is fixed effects estimation. It assumes that the unobserved component in the regression is constant over time and by creating dummies for every exporter and importer included in the estimation all country specific effects are taken into account. These dummies are each equal to unity every time a particular exporter or importer appears in the dataset. The coefficient of the dummies for the importer and exporter should reflect the multilateral resistance of each country.

Before I rewrite the gravity equation in terms of fixed effects it seems appropriate to augment the gravity equation given by Anderson and van Wincoop. It is commonly accepted that the geographical distance may be a poor approximation of all the economic barriers for international trade (Herrera & Baleix 2010). To control better for these omitted variables the general gravity equation by Anderson and van Wincoop has been completed by a range of variables depending on the focus of the relevant empirical paper. It is common to include dummy variables for adjacency (a dummy that takes value 1 if trade partners share a common border, 0 otherwise), common language (sharing language should make all transaction easier and might have positive effect on bilateral trade), colonial links (this can either mean to have a common coloniser or to have been colonised by the other country in the past), regional trade agreement, RTA (1 if both countries are members of a trade agreement, 0 otherwise), and many more. Grouping terms together

for exporters and importers and taking logs, I rewrite the stochastic equation from (3.3.7) as in Shepherd (2012):

$$\ln X_{ij} = -\ln Y_w + \ln Y_i + \ln Y_j + (1-\sigma)\ln t_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j + \ln \epsilon_{ij} \quad (3.4.2)$$

The logarithmic specification of the equation allows an easy interpretation of the estimated parameters: the parameters of an equation estimated in logarithms are elasticities. So the estimated in logarithms parameter for GDP, for example, is the elasticity of trade to GDP, indicating the percentage variation in trade following a 1 per cent increase in GDP.

By putting the terms together this log-linearized form can be rewritten as:

$$\ln X_{ij} = C + F_i + F_j + (1-\sigma)\ln t_{ij} \quad (3.4.3)$$

where

$$C = -\ln Y_w \quad (3.4.4)$$

$$F_i = \ln Y_i - \ln P_i \quad (3.4.5)$$

$$F_j = \ln Y_j - \ln P_j \quad (3.4.6)$$

$$\ln t_{ij} = b_1 \ln distance_{ij} + b_2 adjacency_{ij} + b_3 comlang_{ij} + b_4 colony_{ij} \quad (3.4.7)$$

The estimation of fixed effects model seems easy and straightforward. It provides a convenient way to consistently estimate the theoretical gravity model: unobservable multilateral resistance is accounted for by dummy variables. However this way of estimating also poses a major restriction on the model: variables that vary only in the same dimension as the fixed effects cannot be included in the model, because they would be perfectly collinear with the fixed effects, and therefore needs to be dropped from the model. This restriction means that it is not possible to include in the model data that vary only by exporter (constant across all importer) or by importer (constant across all exporter). But

unfortunately most of the policy data are exactly such that they vary only by exporter or by importer. The country-pair fixed effect will then take out of the gravity equation important variables such as land area, common language, common borders or distance, and consequently, the effect of these variables on bilateral trade cannot be estimated.

One way of dealing with this problem is to take variables that vary by exporter or importer and transform them artificially into a variable that varies bilaterally. Such variables can then be included in the fixed effects model without any difficulty (Shepherd 2012). Another weakness when using fixed effects estimation method with OLS is that zero-observations in trade matrices are disregarded due to the fact that the natural logarithm of zero is undefined.

The panel data provides an alternative to fixed effects estimation that still account for unobserved heterogeneity, but allows the inclusion of variables that would be collinear with the fixed effects (WTO and UNCTAD 2012). The problem of collinearity usually arise from cross-section data, but is completely avoided with panel data. In this case the exporter and importer fixed effects are time-varying. Another standard problem in the cross-section empirical work is the potential endogeneity of right-hand-side variables. If a RHS variable is correlated with the the error term, then it is considered econometrically endogenous and an OLS regression analysis may yield biased and inconsistent coefficient estimates. Potential sources of endogeneity bias of RHS variables are generally omitted variables, simultaneity and measurement error (Baier & Bergstrand 2007) *"Do Free Trade Agreements Actually Increase Members' International Trade?"*. According to their research, countries are likely to select endogenously into FTAs, for reasons probably unobservable for econometricians. This issue of endogeneity bias in estimating the effect of trade policies on trade volumes is addressed by Baier and Bergstrand by use of instrumental-variables (IV), control-function (CF), and panel-data techniques. The reason for why this is important to take into account is because if the FTAs are endogenous, as it is argued for, then all the previous empirical estimates of the effects of FTAs on trade flows may be biased and inconsistent, and the effect of FTAs on trade may be seriously over - or under-estimated. When accounting econometrically for the FTA variable´s endogeneity they find a "striking" empirical result: the effect of FTAs on trade flows quintuples. This shows that the panel data approach is the better estimation method, only not with use of OLS. I review in later section that Poisson Pseudo Maximum Likelihood estimation method is better at accounting for problems with zero-observations

and heteroskedasticity (Silva & Tenreyro 2006).

### 3.4.3 Taylor approximation - an alternative to fixed effects estimation

To avoid the issue of unobservable multilateral resistance terms without using fixed effects estimation, Baier & Bergstrand (2009) use a simpler approach to this estimation problem by applying first-order Taylor approximation to the gravity equation, rewriting it such that good old OLS can be used when estimating, instead of NLS. In addition, they argue that without the structural system of nonlinear equations there is still not possible to generate region - or pair-specific general equilibrium (GE) comparative statics. The criticism is that fixed effects estimation precludes estimating multilateral resistance terms with *and* without economic integration agreements (EIAs), but can not be used to construct a system of nonlinear equations to estimate multilateral resistance terms with and without the "border", meaning an estimation of country-specific border effects. They demonstrate that using their first-order Taylor approximation technique and estimating the gravity equation parameters with OLS they find almost identical parameters as in Anderson and van Wincoop, but importantly enough allowing for asymmetric bilateral trade costs, $t_{ij} \neq t_{ji}$, (which are assumed symmetric in Anderson and van Wincoop).

A first order Taylor-series expansion of any function $f(x_i)$ centred at $x$ is given by $f(x_i) = f(x) + f'(x)(x_i - x)$. Applied to the multilateral resistance terms in equations (3.3.8) and (3.3.9) they derive following MR terms:

$$lnP_i = \sum_{j=1}^{N} \frac{Y_j}{Y_w} ln\tau_{ij} - \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{Y_i}{Y_w} \frac{Y_j}{Y_w} ln\tau_{ij} \tag{3.4.8}$$

$$lnP_j = \sum_{i=1}^{N} \frac{Y_i}{Y_w} ln\tau_{ij} - \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{Y_i}{Y_w} \frac{Y_j}{Y_w} ln\tau_{ij} \tag{3.4.9}$$

These two terms can be inserted into the log-linearized version of the gravity model in equation (3.4.2) to get:

$$lnX_{ij} = C + lnY_i + lnY_j + (1-\sigma)ln\tau_{ij} - (1-\sigma)\left[\sum_{j=1}^{N}\frac{Y_j}{Y_w}ln\tau_{ij} - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{Y_i}{Y_w}\frac{Y_j}{Y_w}ln\tau_{ij}\right] - (1-\sigma)\left[\sum_{i=1}^{N}\frac{Y_i}{Y_w}ln\tau_{ij} - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{Y_i}{Y_w}\frac{Y_j}{Y_w}ln\tau_{ij}\right] + ln\varepsilon_{ij}$$

where $C = -lnY_w$

or simplified by somewhat:

$$lnX_{ij} = C + lnY_i + lnY_j + (1-\sigma)ln\tau^*_{ij} + ln\varepsilon_{ij} \tag{3.4.10}$$

where

$$ln\tau^*_{ij} = ln\tau_{ij} - \sum_{i=1}^{N}\frac{Y_i}{Y_w}ln\tau_{ij} - \sum_{j=1}^{N}\frac{Y_j}{Y_w}ln\tau_{ij} + \sum_{i=1}^{N}\sum_{j=1}^{N}\frac{Y_i}{Y_w}\frac{Y_j}{Y_w}ln\tau_{ij} \tag{3.4.11}$$

Baier and Bergstrand apply their approach to McCallum's US-Canada case and show that they can generate same gravity equation coefficient estimates as those generated using the technique in (Anderson & Wincoop 2003), but again instead of NLS using OLS with exogenous multilateral resistance terms. They replace the unobservable theoretical trade-cost variable $\tau_{ij}$ with an observable variable by using bilateral distance ($DIS_{ij}$) and a dummy representing the presence or absence of an economic integration agreement ($EIA_{ij}$). A dummy variable, $BORDER_{ij}$ is such that $EIA_{ij} \equiv 1 - BORDER_{ij}$, assuming a value of 1 if regions $i$ and $j$ are *not* in the same nation. With data on trade flows, GDPs, bilateral distances and borders in place they estimate the equation using OLS and confirm by Monte Carlo simulations that their OLS method yields virtually identical estimates of border and distance coefficients as those by Anderson and van Wincoop's NLS method.

I will not apply first order Taylor approximation to my gravity equation in the later discussions, because I will use fixed effects to account for unobservable multilateral resistance terms. Nonetheless I believe it is important to review this approach as it elegantly solves the problem of unobservable terms and allows for a simple estimation of the equation.

### 3.4.4 Poisson Pseudo Maximum Likelihood estimation (PPML)

Silva and Tenreyro (2006) present an intuitive and simple solution that fixes the problems of zero observations and heteroskedasticity. The essential point is that "the log linearisation of the empirical model in the presence of heteroskedasticity leads to inconsistent estimates because the expected value of the logarithm of a random variable depends on higher-order moments of its distribution" (Silva and Tenreyro, 2006, p. 653).

Recall the basic multiplicative gravity equation from (3.2.1):

$$X_{ij} = GS_iM_j\phi_{ij}\epsilon_{ij} \tag{3.4.12}$$

where $G$ is a gravity constant that varies over time in a panel data analysis, $S_i$ represents all characteristics of the exporter country $i$, $M_j$ represents all country characteristics of $j$, $\phi_{ij}$ represents geographical distance between exporter $i$ and importer $j$, and $\epsilon_{ij}$ is the error term, the specification of which is crucial for choice of estimation of the gravity model. When the error term is normally distributed there are certain assumptions that needs to be fulfilled in order for the model to yield unbiased and consistent estimates. Most important of these are the assumption of constant mean, $E(\epsilon_{ij}) = \mu$ and constant variance, $var(\epsilon_{ij}) = \sigma^2$. The assumption of constant variance implies that all observations in the model come from probability density function with the same variance. Silva & Tenreyro (2006) argue in their paper that when the gravity model is log-linearized the log-linearized error term changes its properties and thus lead to inefficient estimations due to heteroskedasticity. Heteroskedasticity implies that the error term's expected value is no longer constant (or zero) and its variance is no longer a constant, but rather a function is the regressors. The expectation of the error term in case of homoskedasticity are given as: $E(\epsilon_{ij}|S_i, M_j, \phi_{ij}) = 1$, i.e. the error term is independent of the regressors.

Log-linearizing the basic equation is as follows:

$$\ln X_{ij} = \ln G + \ln S_i + \ln M_j + \ln \phi_{ij} + \ln \epsilon_{ij} \tag{3.4.13}$$

Taking conditional expectation of this equation yields:

$$E(ln(X_{ij})|(S_i, M_j, \phi_{ij})) = E(ln(X_{ij})|lnG + lnS_i + lnM_j + ln\phi_{ij} + ln\epsilon_{ij}) \tag{3.4.14}$$

Applying the additive property of the expected value, obtain further:

$$E(ln(X_{ij})|(S_i, M_j, \phi_{ij})) = lnG + lnS_i + lnM_j + ln\phi_{ij} + E(ln(\epsilon_{ij})|(S_i, M_j, \phi_{ij})) \quad (3.4.15)$$

All of the coefficients, including the intercept, are estimated consistently if and only if $E(ln(\phi_{ij})|(S_i, M_j, \epsilon_{ij})) = 0$ holds. From before we know that $E(\epsilon_{ij}|S_i, M_j, \phi_{ij}) = 1$, and taking log of this yields $ln(E(\epsilon_{ij})|(S_i, M_j, \phi_{ij})) = 0$. However, due to Jensen's inequality the result is such that:

$$ln(E(\epsilon_{ij})|(S_i, M_j, \phi_{ij})) \neq E(ln(\epsilon_{ij})|(S_i, M_j, \phi_{ij})) \quad (3.4.16)$$

meaning that the logarithm of the expected value of a random variable is different from the expected value of the logarithm. According to Jensen's inequality the usual practice of interpreting the parameters of any log-linearized models estimated by regular OLS as elasticities can, in presence of heteroskedasticity, be highly misleading and potentially bias. Applied to trade theory, Jensen's inequality means that total predicted trade exceeds total actual trade. In their research, Silva and Tenreyro found out that the log-linearized OLS estimation of the gravity model greatly exaggerates the effects of GDP, geographical proximity and of colonial ties on the bilateral trade flows. The presence of heteroskedasticity can yield largely overestimated coefficients even controlling for fixed effects when the gravity equation is log-linearized rather than being estimated in levels. As a result of this the t-values for the estimated coefficients cannot be trusted. In addition, as I mentioned previously, another problem with log-linearization is that it is incompatible with the existence of zeros in trade data, which leads to elimination of zero-trade pairs.

Silva and Tenreyro propose, as a solution to these problems, to estimate the model in levels, instead of taking logarithms. They suggest two alternative to OLS methods: nonlinear least squares (NLS) and Poisson Pseudo Maximum Likelihood (PPML), and conclude that PPML is more preferred. By performing Monte Carlo simulations they show that their method is robust to different patterns of heteroskedasticity, in addition to providing a natural way of dealing with zeros in trade data. The Poisson-PML estimator identifies the coefficients using the same first-order conditions that are used by the maximum-likelihood estimator derived from the Poisson distribution. Though Poisson-PML does not require the dependent variable to be Poisson distributed.

The Poisson is consistent in presence of fixed effects and what is more beautiful is that it naturally includes observations for which the observed trade vales are zero. Another

thing that is good with PPML estimation is that it allows to interpret the coefficients in the same pattern as under OLS estimation. Even though the dependent variable for Poisson regression is defined as exports in levels and not in logarithms, the coefficients of any independent variables entered in logs can still be interpret as simple elasticities. The coefficient of the independent bilateral export variable entered the gravity equation in levels will be interpret as semi-elastic, as under OLS.

### 3.4.5 Endogeneity of FTA

In their empirical paper on endogeneity of the preferential trade agreements (PTAs), Egger et al. (2011) use the non-linear multiplicative form of the gravity equation with country fixed effects, and argue that the conditional error term of the equation is not unity and hence the PTA variable is not exogenous, as many empirical researches in international trade claim, but rather endogenous. By acknowledging the potential endogeneity of the membership in a PTA, they allow for correlation between the error term $\epsilon_{ij}$ and the propensity to form an agreement. They tackle this problem by introducing an instrumental variable method that is based on the joint distribution of the error term $\epsilon_{ij}$ and PTA. The problem with endogeneity of PTA is that, as mentioned previously, there is a possible reverse causality between a country pairs' trade and their decision to become members in a trade agreement. Until now it has been obvious that different trade agreements lead to higher bilateral trade between member countries, but it is also so that the countries that trade more from before are most likely to form or engage in a trade agreement. By introducing an instrumental variable approach Egger et al. (2011) account for that issue. In econometrics, endogeneity of an explanatory variable implies that the OLS assumption of orthogonality (that the error term must be uncorrelated with each of the explanatory variables) is violated and there is in fact a correlation between this endogenous variable and the error term.

Egger et al. (2011) paper is unique because the authors unify the three important issues in gravity equation estimation in one and try to account for all three in a unified framework. By including importer and exporter fixed effects they account for the unobserved multilateral resistance terms; the Poisson PML estimation is used in the two-stage estimation of multiplicative gravity model so as to account for the zero trade flows; the reverse causality, occurring because of endogenous PTA variable, is accounted for by introducing instrumental variables. Estimation with instrumental variables is difficult because it is

hard to prove the validity of the instruments used in the regressions.

With reference to my thesis, I believe the issue of reverse causality is highly possible due to political and historical relationships between countries of Eurasian Economic Union. Having been members of Soviet Union for many years, countries of Eurasian regional integration share not only common borders, have a common Russian language (though not official) that most of them speak, and cultural and historical ties that have been much of the reasons as to why they have large trade flows prior to any Union. Hence introducing instrumental variables would be very helpful in accounting for endogeneity of EIA in the form of Eurasian regional integration in my thesis. But finding valid instruments is not easy, because not only do they have to pass tests for validity, but they also have to be significantly correlated with the probability of forming trade agreements, i.e. relevant. This is a time consuming process and out of the scope of my thesis, but yet I wish to stress the importance of endogeneity of free trade agreement variables and their causal effect on the bilateral trade flows.

# 4 Estimation

In this chapter I present and estimate my own gravity equation, building it on the theory given in the previous chapter. Here I discuss the data, variables and the methodology of the estimation and later investigate and interpret the results. The aim is to set up and perform the Poisson Pseudo-Maximum Likelihood panel data estimation and compare it with the traditional panel data estimation technique based on the logarithmic transformation of the gravity equation. These proposed estimation techniques are applied on real panel dataset of 45 countries over four years. I wish to base some parts of my approach on Baier, Bergstrand, Egger & McLaughlin (2008) *"Do Economic Integration Agreements Actually Work? Issues in Understanding the Causes and Consequences of the Growth in Regionalism"*, who look at what are the underlying causes of growth in regional integration agreements. They define economic integration agreements (EIAs) to be inclusive of all free trade agreements (FTAs), customs unions, common markets and economic unions, and for the purpose of my thesis I do the same - in this chapter I define a variable EIA that is inclusive of all economic integrations agreements, and then I restrict it to integrations agreements such as EU, Eurasian Economic Union, etc. The effects these dummy variables for economic integration agreements have on my dependent variable, the bilateral exports, are the main focus of my estimations. I first describe the dataset and the sources from which it is gathered, then I discuss the econometric specification and some of the descriptive statistics of the data, and finally I present and discuss the results of my own estimations.

## 4.1 Data Sources

The dataset combines data on bilateral trade relations for 45 countries over 4 years, 2010-2013. It is constructed for these four years because the Customs Union between Belarus, Russia and Kazakhstan came into force in 2010 and I use bilateral exports data since then. The data is gathered from five separate sources and contains data on bilateral exports, GDP, trade agreements, bilateral distance and a number of historical and cultural relations. The purpose of this section is to explain how the different data sources have been adapted and put together to make the final gravity dataset, and to discuss its strengths and limitations.

I use data on nominal bilateral export flows in current US dollars from the International Monetary Funds' Direction of Trade Statistics (IMF DOTS) for 45 economies (see Ap-

pendix C for a list of countries) over the years 2010-2013. I do this just as Baier et al. (2008) do in their paper, when they define nominal bilateral trade flows for years 1960-2000 for 96 potential trading partners. Bilateral export flows means all trade exports, in total. Most of the data on bilateral trade export flows for 2010 is from United Nations' Commodity Trade Statistics Database (UN Comtrade). The nominal bilateral exports are then scaled by GDP deflator from World Bank's World Development Indicators, with base year that varies by country. I scale my data in the same way Baier et al. (2008) do in their paper, and this is done so in order to generate real trade flows for the panel analysis. I restrict my number of economies to 45 countries because these are the ones of interest for my estimations - all EU countries, all countries that are in CISFTA, BRIC countries (South Africa omitted) plus USA, New Zealand and Australia. CISFTA is a free trade agreements between countries in the Commonwealth of Independent States, such as Armenia, Azerbaijan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. These are natural countries to include when considering regional integration between Belarus, Kazakhstan and Russia, because these three countries trade extensively with all the CIS countries and are also members of the CISFTA. The inclusion of the BRIC is maybe not as natural. China is one of the most important trading partner for both Russia and Kazakhstan, being the world's largest importer of oil products, while India and Brazil are not as important, but I believe being one of the largest emerging economies they too should be included. The problem with the BRIC variable is that BRIC is not a free trade agreement, it is only an association of five major emerging economies (Brazil, Russia, India, China and South Africa), and so in my estimations the BRIC variable has zero value, because there is no trade agreement within it. There exists extensive trade between these countries, but no free trade agreement. Years 2010-2013 covers period during which The Eurasian Customs Union between Russia, Belarus and Kazakhstan has been enacted (in 2010), with establishment of Single Economic Space between these countries in 2012.

To measure country characteristics I use Gross Domestic Product (GDP) measured in current US dollars. For this purpose I use data from World Bank´s World Development Indicators for all 45 economies over the period of 4 years. These are also scaled by GDP deflator for 2010-2013, to generate real GDP's for the panel analysis.

The French CEPII institute (Centre d´Etudes Prospectives et d´Informations Internationales) has published a dataset containing many of the variables and dummies commonly used in gravity estimations. GeoDist dataset provides several country-specific geographi-

cal variables. The primary variable of interest for my purpose is the measure of bilateral distances between countries. In addition there are bilateral dummies on whether or not countries are contiguous (share common border), whether or not they have a common official language, or if they have been in a colony or had a common coloniser, etc.

The most important variable of interest is the EIA dummy variable indicating whether given pair of exporters and importers are partners in a trade agreement. The data is constructed by De Sousa (2011) and is gathered from three different sources - Table 3 of Baier & Bergstrand (2007) *"Do Free Trade Agreements Actually Increase Members' International Trade?"*, the most recent WTO list of all RTAs in force and qualitative information contained in Frankel (1997) *"Regional Trading Blocs in the World Economic System"*. I divide the EIA dummy variable constructed from this into five different unions - EU, CISFTA, EEU, BRIC and a variable called otherFTA, that contains information on the trade agreements between China and New Zealand, Australia and New Zealand, and Australia and USA. Notice here that BRIC does not have any trade agreement and therefore has zero value in the regression analysis.

## 4.2 Econometric Specification

### 4.2.1 The model specification and variables

In general, the traditional estimates of gravity equation use data on country pairs that trade in one direction, reporting either exports or imports. So instead of constructing symmetric trade flows for each country pair by combining exports and imports I use a unidirectional trade value in terms of exports and then introduce fixed effects for both exporting countries and importing countries. This way the fixed effects represent a country pair twice: first as exports from country $i$ to country $j$, and then as exports from country $j$ to country $i$. There are then 45 x 44 = 1980[13] possible bilateral trading relationships, and summing over 4 years there are 45 x 44 x 4 = 7920 observations.

With accordance to the theoretical gravity equation concept, I define bilateral exports from country $i$ to country $j$ in year $t$, $X_{ijt}$ as a stochastic function of economic variables representing GDP for country $i$ in year $t$, $Y_{it}$, GDP for country $j$ in year $t$, $Y_{jt}$, bilateral resistance to trade represented by the distance between countries, $Dist_{ijt}$, a number of

[13] *N countries give N(N-1) bilateral country pairs, that is with 45 countries in my dataset this gives: 45*44 = 1980.*

proxies for trade costs (dummy variables), such as whether or not a pair of countries share common official language ($comlang - off_{ijt}$), whether the two countries are contiguous ($contig_{ijt}$), have ever had a colonial link ($colony_{ij}$), have had a common coloniser after 1945 ($comcol_{ij}$) or whether or not a pair of countries were/are the same country ($smctry_{ij}$). These dummy variables are important for the purpose of my estimations, because as I have stressed previously, the cultural and historical ties between post-Soviet countries of Belarus, Russia and Kazakhstan are much of the reasons as to why an economic regional integration between them is not a senseless affair. I have a policy variable for regional trade agreements that I call $EIA_{ij}$, that I then further divide into 5 different variables (dummies): $EU_{ij}$, $BRIC_{ij}$, $EEU_{ij}$, $CISFTA_{ij}$ and $otherFTA_{ij}$ that contains information on free trade agreements between China and New Zealand, Australia and New Zealand and Australia and USA. $BRIC_{ij}$ variable is omitted from every regression in my model, because the BRIC countries do not have a free trade agreement. Fixed effects are represented by $\alpha_{it}$ and $\alpha_{jt}$, the exporter and importer time varying, respectively. I also include country-pair fixed effects $\alpha_{ij}$ that controls for the impact on trade of the different characteristics such as distance between countries, common language, colonial status and other observed and unobserved characteristics that are constant over time. And lastly, there is the error term $\epsilon_{ijt}$. The stochastic multiplicative gravity model for international trade is then given as:

$$X_{ijt} = \beta_0 Y_{it}^{\beta_1} Y_{jt}^{\beta_2} Dist_{ijt}^{\beta_3} e^{U_{ijt}} \epsilon_{ijt} \tag{4.2.1}$$

where $U_{ijt}$ is a vector of institutional, historical and policy factors:

$$\begin{aligned} U_{ij} = {} & \beta_4 comlang_{ijt} + \beta_5 contig_{ijt} + \beta_6 colony_{ijt} + \beta_8 smctry_{ijt} + \beta_9 EU_{ijt} \\ & + \beta_{10} EEU_{ijt} + \beta_{11} CISFTA_{ijt} + \beta_{12} BRIC_{ijt} + \beta_{14} otherFTA_{ijt} + \alpha_{ij} + \alpha_{it} + \alpha_{jt} \end{aligned}$$

The logarithmic transformation of the above given equation will yield this simple log-linearized gravity equation:

$$lnX_{ijt} = ln\beta_0 + ln\beta_2 Y_{it} + ln\beta_3 Y_{jt} + U_{ijt} + ln\epsilon_{ijt} \tag{4.2.2}$$

Remember that this way of specifying the equation allows for interpretation of the coefficients as elasticities. I regress the model first as simple OLS, then as OLS with fixed effects.

### 4.2.2 PPML with fixed effects estimation

As discussed in section 3.4.4, the Poisson Pseudo Maximum Likelihood estimation is excellent in helping to avoid the heteroskedasticity and zero-observation bias. Thus I modify my equation in (4.2.2) and rewrite it in PPML terms, with exports variable in levels on LHS while keeping all other variables on the right hand side in log forms:

$$X_{ijt} = ln\beta_0 + ln\beta_2 Y_{it} + ln\beta_3 Y_{jt} + U_{ijt} + ln\epsilon_{ijt} \tag{4.2.3}$$

The vector of institutional and policy factors $U_{ijt}$ is the same as before. This way of specifying the equation still allows for interpretation of the coefficients as in the usual log-linearized OLS model, because the RHS variables remain in the log form.

So, summarised, I control for the multilateral resistance terms, emphasised by Anderson and van Wincoop, by use of fixed effects estimation. This I can do because my variable of interest, $EIA_{ijt}$ (and the restricted version of it), varies between countries bilaterally. I estimate the traditional log-linearized gravity equation with importer and exporter fixed effects and country-and-time fixed effects in a panel data. Then, in order to eliminate the potential heteroskedasticity in the error term and selection bias from using OLS estimation (both with and without fixed effects) I use PPML estimator as suggested by Silva & Tenreyro (2006).

## 4.3 Descriptive Statistics

Table 1 reports summary for the main variables that are used in the estimations. This description is useful as to see what values the variables have and to an extend how much significance they have. For instance, the EIA dummy shows that out of 1980 bilateral trade relations 44% are fellow members of a trade agreement. When I restrict the EIA dummy variable to yield specific trade agreements and unions I get more specific percentage. For instance, only 0,6% out of 1980 bilateral relations are that of those countries who are members of Eurasian Economic Union. European Union accounts for almost 38% of bilateral relations, as the largest integration project among them. The standard deviations imply that the effects of explanatory variables on trade flows vary, sometimes substantially, as in the case of effect of distance on trade flows, or marginally, as for regional trade agreement dummies.

**Table 1:** Summary statistics

| Variable | Mean | Standard deviation | Min. | Max. |
|---|---|---|---|---|
| Log of exporter GDP | 25.357 | 2.397 | 20.352 | 30.305 |
| Log of importer GDP | 25.357 | 2.397 | 20.352 | 30.305 |
| Common language | 0.037 | 0.19 | 0 | 1 |
| Contiguity | 0.068 | 0.25 | 0 | 1 |
| Colony | 0.033 | 0.18 | 0 | 1 |
| Common colonizer | 0.082 | 0.274 | 0 | 1 |
| Log of distance | 7.863 | 1.024 | 4.088 | 9.883 |
| Same country | 0.02 | 0.139 | 0 | 1 |
| European Union | 0.379 | 0.485 | 0 | 1 |
| CISFTA | 0.056 | 0.229 | 0 | 1 |
| BRIC | 0 | 0 | 0 | 0 |
| Eurasian Economic Union | 0.006 | 0.078 | 0 | 1 |
| Other FTAs | 0.003 | 0.056 | 0 | 1 |
| EIA dummy | 0.441 | 0.497 | 0 | 1 |

### 4.3.1 Correlation matrices

An initial and logical place to start with evaluating the model would be the correlation matrix, to see whether or not the intuition behind the gravity model is consistent with the regression at hand. Table 2 contains correlations between selected variables. Overall the correlations given in the table are consistent with the general intuition. There is, as expected, negative linear correlation between distance and bilateral exports - as distance increases, bilateral trade decreases. Same is true for correlation between distance and the EIA dummy - the larger is distance between given pair of countries, the less is the possibility that they will form a regional trade agreement. On the contrary, there is positive linear association between GDP's and exports - bilateral trade increases when both exporter and importer countries experience welfare gain in form of increased GDP.

The evidence of positive relationship between GDP of trading partners and bilateral trade, and of negative relationship between distance and bilateral trade are consistent with theory. But these correlations do not control for other potential influences and do not equate to causation. They are also subject to considerable deviations, in particular at low GDP and high distance. I do not draw any conclusions from this correlation matrix, as a formal estimation is needed for such, but still it is useful to see the relationship between the variables so as to get a general sense of the behaviour in the data.

**Table 2:** Correlation matrix on selected variables

| Variables | Log exports | Log distance | Log importer GDP | Log exporter GDP | EIA |
|---|---|---|---|---|---|
| Log exports | 1.000 | | | | |
| Log distance | -0.252 | 1.000 | | | |
| Log importer GDP | 0.466 | 0.107 | 1.000 | | |
| Log exporter GDP | 0.544 | 0.107 | -0.023 | 1.000 | |
| EIA dummy | 0.317 | -0.638 | 0.031 | 0.030 | 1.000 |

## 4.4 Estimation Results

Table (3) presents empirical results of five different estimations of gravity equation (4.2.2). These are estimated using panel data of real trade flows ($X_{ijt}$), real GDPs for country $i$ and

country $j$, $Y_{it}$ and $Y_{jt}$ respectively, and a vector of historical and policy factors, in which the EIA dummies are most important ($EU_{ijt}, EEU_{ijt}, CISFTA_{ijt}, BRIC_{ijt}, otherFTA_{ijt}$). There are also alternative specifications with and without bilateral fixed effects and time dummies. The first column provides the baseline gravity equation estimated with OLS without any fixed effects or time dummies for all four years. This is representation of the "naive" log-linear model which drops all data points for which bilateral exports are zero, does not account for multilateral resistance terms and also treats EIA dummies as exogenous. Columns (2) is output of OLS estimation of gravity equation with importer and exporter time fixed effects, while column (3) provides results of OLS estimation of the equation with importer and exporter fixed effects, country pair and time dummies. The estimations in columns (1)-(3) cannot be used to discuss the impact of economic integration agreements on the dependent variable, and are only included for robustness and general comparison with what has been discussed previously in the gravity model literature. Columns (4) and especially (5) contain my main regression results. As proposed by Silva & Tenreyro (2006) I use the Poisson PML estimation method in order to account for zero observations in my dataset and also to avoid the issue of heteroskedasticity of the error term. In column (4) I ran the PPML estimation without any fixed effects, while column (5) presents results of Poisson PML estimation with bilateral fixed and country-and-time effects. In these methods of regressions I follow Shepherd (2012) who gives a good overview of wide range of Stata commands for different regressions of the gravity model.

In both results given in columns (4) and (5) the EIA variables are also treated exogenously. As I briefly discussed in section (3.4.5) in order for the EIA dummies to be considered endogenous I would have to use a two-stage Poisson PML estimation with instrumental variables. As this is outside of the scope of my thesis I do not try to account for the issue of endogeneity, but I wish to stress the importance of the issue and the significance it would have on the final estimation results.

**Table 3:** Regression results

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Independent variables | OLS | Fixed effects OLS | Fixed effects OLS | PPML | Fixed effects PPML |
| | | Dependent variable: Log of exports | | Dependent variable: Exports | |
| Log exporter GDP | 1.171*** | | | 0.278*** | |
| | (0.018) | | | (0.080) | |
| Log importer GDP | 1.031*** | | | 0.667*** | |
| | (0.014) | | | (0.111) | |
| Log distance | -1.741*** | -1.155*** | -1.155*** | -0.296*** | -0.296*** |
| | (0.065) | (0.145) | (0.146) | (0.099) | (0.099) |
| Contiguity | 0.266** | 0.0639 | 0.0645 | 0.421*** | 0.421*** |
| | (0.112) | (0.392) | (0.391) | (0.111) | (0.111) |
| Common language | 0.178* | 0.989 | 0.987 | 0.414** | 0.416*** |
| | (0.0997) | (0.921) | (0.925) | (0.161) | (0.161) |
| Colony | 0.968*** | 0.929 | 0.931 | 0.205 | 0.201 |
| | (0.136) | (0.590) | (0.593) | (0.127) | (0.127) |
| Common colonizer | 2.070*** | 1.858*** | 1.856*** | 1.407*** | 1.294*** |
| | (0.165) | (0.0439) | (0.0408) | (0.368) | (0.372) |
| Same country | -1.756*** | -1.357*** | -1.357*** | 0.483** | 0.485** |
| | (0.391) | (0.353) | (0.352) | (0.196) | (0.196) |
| EU | 0.242*** | 0.141 | 0.140 | 0.957*** | 0.966*** |
| | (0.0733) | (0.133) | (0.134) | (0.250) | (0.248) |
| CISFTA | 1.482*** | 2.791*** | 2.792*** | 1.444*** | 1.500*** |
| | (0.209) | (0.0769) | (0.0741) | (0.419) | (0.401) |
| EEU | 0.514 | 0.799*** | 0.829*** | 1.406*** | 1.499*** |
| | (0.335) | (0.277) | (0.274) | (0.484) | (0.429) |
| otherFTA | 1.297*** | 0.898*** | 0.895*** | -0.425 | -0.426 |
| | (0.220) | (0.263) | (0.264) | (0.258) | (0.260) |
| Constant | -38.89*** | -81.69*** | -53.73** | -19.17*** | -65.32*** |
| | (0.763) | (18.00) | (22.06) | (3.354) | (14.73) |
| Fixed effects | | YES | YES | | YES |
| Observations | 7,915 | 7,915 | 7,915 | 7,919 | 7,919 |
| R-squared | 0.694 | 0.793 | 0.793 | 0.908 | 0.908 |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

## 4.5 Discussion of the results

The Customs Union between Russia, Kazakhstan and Belarus, with removal of internal customs posts and implementation of common external imports tariff, came into force in 2010. Since then trade among these countries has grown significantly. For example, trade exports between Russia and Kazakhstan in 2011 increased almost twice in comparison to 2010, while exports from Kazakhstan to Russia doubled from 2010 to 2011, and continued to increase since then. Same goes for exports from Russia to both Kazakhstan and Belarus. Belarus and Kazakhstan trade little with each other, but even their turnover increased largely since Customs Union began its operations. This is obvious from looking at the coefficient of interest, EEU, which large in magnitude and highly significant. Exports will, on average, be about 83% higher if exporting to a fellow member of Eurasian trade agreement when gravity equation is estimated with fixed effects OLS, and a whole 150% higher once estimated with fixed effects PPML. The coefficient value for EU is also large and significant with PPML estimation, meaning that being a member of EU increases member country's international trade with about 96%. Both EU and EEU coefficients yield very large values when estimated with PPML method, and there might be several reasons for this, that I wish to shortly speculate over.

Baier & Bergstrand (2007) and Baier et al. (2008) discuss fixed effects estimations of the theoretically motivated gravity equation with so-called "phased-in" trade agreements, meaning that economic integration agreements do not yield consistent results right away, and are rather phased in over time, typically five to ten years. Thus, they argue, it is reasonable to include lagged levels of the EIA dummies. Results in both papers show statistically significant lagged effects on trade flows. For instance, Baier et al. (2008) coefficient estimate for EU yields result that membership in EU increases trade by 100% (Baier et al. (2008) p.487), while membership in any other EIA increases trade by almost 60%. Thus, if I were to include lagged effects for both EU and EEU variables, their estimates would probably not be as large as they are now without any lagged values, and the coefficient estimates would yield plausible values, balanced across periods. This explains to an extend large coefficient estimates in current period for EU and EEU. Another reason as to why the coefficients for EU and EEU dummies are high and significant, is because PPML estimation corrects for zero trade, thus including bilateral export relations even if they are very very small in values. Intra-European trade is to be expected to enhance because of geographical proximity (short distance between countries), cultural ties and even common language in some cases, something that empirical findings in my gravity

estimation and many other research papers support. Also, the significantly large effect of CISFTA on bilateral exports is explained by the fact that the countries of Commonwealth of Independent States are either landlocked, have had common coloniser or been same country before, and hence have tendency to trade largely with each other. In column (5) the positive and significant coefficient for CISFTA suggest that on average the CIS countries trade 150% more once in a free trade agreement. The *home bias* effect, first introduced by McCallum (1995) can also give some explanation for these rather high trade flows, both between CIS countries and countries of EEU.

When Silva & Tenreyro (2006) first introduced estimations by Poisson Pseudo Maximum Likelihood as opposed to OLS estimations, they performed a number of Monte Carlo simulations comparing the estimates from PPML approach with those of OLS, and found that in presence of heteroskedasticity estimates obtained using log-linearized models are highly biased, thus distorting interpretation of the model. This way they show that the OLS estimates, whether significant or not, can not yield unbiased estimates once heteroskedasticity is present. Further, Silva & Tenreyro (2006) show that OLS greatly exaggerates the roles of colonial ties and geographical proximity. This is also true seen with respect to my own estimations, when PPML estimate for distance decreases to a value of 0.296 in absolute terms, from an initial OLS value of 1.741 - as geographical distance between a pair of countries increases, their bilateral trade decreases by about 30%. This means that, after controlling for bilateral distance, sharing a border does not influence trade as much as it is given by OLS estimates. This largely reflects the impact of heteroskedasticity on the original OLS estimates, for which Poisson gravity regression controls for. Notice that when estimated by PPML method, the coefficients for importer and exporter GDP's are also smaller than those in OLS estimation, showing, as it has been discussed by several trade researchers, that the effect of GDP on bilateral trade does not necessarily equal to unity, as it was assumed previously. Interestingly, Poisson estimates indicate that colonial ties do not play a substantial role for whether or not countries trade extensively, as was also pointed out by Silva & Tenreyro (2006) - coefficient values for variable *colony* does not have any significance in PPML estimation. But the variable for whether or not a pair of countries have had a common coloniser show a significant and positive effect, which is seen with respect to past colonial ties of post-Soviet countries.

The high level of intra-bloc trade between countries of Eurasian regional integration might not be due to the formation of the preferential trade and customs agreement, but to

geopolitical and historical relationship between them, as I have been trying to point out throughout this chapter by looking at significance of the historical and cultural ties between post-Soviet countries. For this reason the establishment of a trade agreement and further integration into an economic unity cannot be considered as an a purely exogenous decision, independent of these relationships, hence the endogeneity of PTAs, as considered by Egger et al. (2011). The authors take into account this problem of endogeneity (yielding reverse causality) and also that bilateral trade flows contain numerous zero entities, omission of which can give insufficient results and potential bias. They introduce instrumental variables, that account for the endogeneity of preferential trade agreement and run PPML estimation with both exogenous and endogenous PTA dummy. The instruments they introduce have an effect on the probability to form a PTA, but they do not have any other, direct effects on exports (as they argue and test for). Their results suggest that the impact of endogenous PTAs on members' relative to non-members' trade flows is 188 percentage points higher than in a model which assumes PTA membership to be exogenous. This result leads them to conclude that failure to regard the PTAs as endogenous biases the coefficient estimates downward. Unfortunately, I cannot say in which way instrumental variables for trade agreements in my estimation would lead coefficient estimates, without having applied the instrumental variable approach to my estimation method.

All in all, there can be many reasons for the rather drastic increase in trade flows between EEU member countries and it is important to understand whether this is due to emergence of Customs Union and subsequent liberalization of trade within the Union, which is the trade creation effect, or if it is because of redirection of existing trade flows from third part countries (outside of the Union) towards CU countries - that is trade diversion. The analysis has in general shown that the integration is an important factor that increased the level of mutual trade between member countries of Eurasian Economic Union in period of 2010-2013. However, one must be cautious with interpretation of this high and positive effect, as it can be explained by many other underlying factors. One possible explanation could be that the trade increased as a natural recovery after the financial crisis of 2008-2009, that would have happened even in absence of a Customs Union being formed. Another explanation for this could be one by Libman & Vinokurov (2010), the *holding together* regionalism effect. It is a view that the post-Soviet countries tend to trade more with each other because they have recently belonged to a single political entity and have intensive infrastructure, economic and social ties between each other.

# 5 Conclusion

The gravity equation is considered as one of the most successful empirical models in economics and has been devoted an extensive attention by researchers ever since Tinbergen (1962). In this master thesis I discuss how the gravity model can be used to account for different economic integration agreements (EIAs), cultural and historical ties and what are the effects of these on international trade flows (exports). My main focus has been on newly established Eurasian Economic Union between Russia, Kazakhstan and Belarus and its effect on export flows of member countries. To see this I have run my own gravity regression using a specified dataset to further supplement the discussion.

In this thesis, I have reviewed the theory of gravity model, both its theoretical and econometrical methodology. I have limited my discussions to what is relevant for my own estimations and hence have not given excessive and complete examination of the model as it is rather large and complex. Taking into account introduction of multilateral resistance terms by Anderson & Wincoop (2003) I control for these by adding fixed effects to my own gravity estimation, and then further account for heteroskedasticity in error terms and omission of zero trade values by estimating the equation with Poisson Pseudo Maximum Likelihood approach introduced by Silva & Tenreyro (2006). My estimations show that membership in the Eurasian Economic Union increases members' trade flows by approximate 150%. This high value is supported by my combined dataset on export flows between countries during years 2010-2013.

The Customs Union between these three post-Soviet countries, only few years in place, has already attracted the attention of researchers. Many analysts tend to portray the Union as largely a geopolitical project, which it most likely is. However, there lies disagreement about its future impact: some view it as a start of further regional integration on the post-Soviet space, and ultimately an instrument for larger economic development, while others fear that the Customs Union between Russia, Kazakhstan and Belarus will lead to more protectionism and perpetuate an inefficient economic structure inherited from the Soviet times. It has not been my intend to give a clear answer to the question of whether or not the Eurasian regional integration will become a driving force for large integration in the Eastern Europe and Central Asia, and whether or not it will lead to more protectionism. I believe that a general assessment of the impact of Customs Union will neither unambiguously be positive or negative - there are winners and there are losers and it is necessary to account for in depth details and nuances. With help of

gravity model estimations I show that there is in fact a positive and significant increase in bilateral exports due to EEU, but I am cautions in my interpretation of these results. The large effect of EEU on intra-regional trade might be due to the existence of *home bias effect*, that is arguably existent in the region that inherent similar economic structures and where countries are located closer to each other than to the rest of the world. It might also be because of *holding together effect*, that is due to the fact that countries have only 24 years ago belonged to a single political entity, or it might be as a post-financial crisis *natural recovery effect*. My conclusions are presented modestly, with attention to robustness and issues of uncertainty.

The gravity model is thought of as a workhorse when it comes to describing the behaviour or trade flows, but cannot be considered to perform well when it comes to describing an economic welfare as such, and I have not addressed any welfare implications of EIAs. Because of data limitations it is often difficult to assess the welfare effects of regional trade agreements and hence the gravity model estimation of such agreements can be seen as a first step in seeing the effects EIA's have on trade flows. Other methods should be used for applications on economic welfare, for instance such as computable general equilibrium (CGE) modelling. CGE models are an effective analytical tool enabling complex ex-ante modelling of the consequences of exogenous policy changes. This type of modelling is also very good when looking at the effects of capital and labor flows across sectors or countries as a result of trade liberalisation, something that the gravity model cannot give any estimation of. But the gravity's comparative advantage is in its ability to use data in order to assess the sensitivity of trade flows to particular trade costs factors, such as different policies. This is why I choose to use gravity model in my thesis, as to see what the effect of a trade liberalising policy between countries in Eurasian Economic Union will be on the international trade flows of these countries.

Eurasian Economic Union is not the first economic or customs union that has been announced on the post Soviet space, nor is it the first time high level political meetings have made bold pronouncements about vital importance of Eurasian economic integration. Even though estimation in this thesis has yielded a positive outcome of EEU on the member countries trade relations, these results are still short-lived and it remains to see how this project will prove itself in the long-run and what kind of welfare effects it will have. And a fair amount of scepticism is to be retained about the future of the Eurasian integration. Much of the progress so far has been without a doubt dependent

on the personalities of the leaders in the three countries, thus making the union very vulnerable to any political changes in the leadership. It is yet too soon to see to what extend the multiple benefits the Eurasian regional integration may materialise, and whether or not numerous challenges can be overcome or at least minimised. Nevertheless, it is still possible to see to some extend what can be learned from the early evidence. This economic integration brings about unique opportunity to build stronger economic and political institutions, but only if certain conditions are fulfilled, which remains to see.

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# A Derivation of Anderson and van Wincoop CES demand function

In the following derivation I use those provided by Theie (2014) in his master thesis *"Non-tariff barriers, trade integration and the gravity model"* at the Department of Economics, University of Oslo.

Maximazation of CES utility function in equation (6) with respect to budget constraint in (7) gives the following Lagrangian:

$$L = \left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} - \lambda\left[\sum_{i=1}^{N} \tau_{ij} p_i c_{ij} - Y_j\right] \tag{A.0.1}$$

First order derivation with respect to $c_{ij}$:

$$\frac{\partial L}{\partial c_{ij}} \equiv \left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{-1}{\sigma}} - \lambda \tau_{ij} p_i = 0 \tag{A.0.2}$$

Multiplying both sides by $c_{ij}$ yields:

$$\lambda \tau_{ij} p_i c_{ij} = \left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \tag{A.0.3}$$

Summing over all $i's$:

$$\lambda \sum_{i=1}^{N} \tau_{ij} p_i c_{ij} = \left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}} \sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \tag{A.0.4}$$

where $\sum_{i=1}^{N} \tau_{ij} p_i c_{ij} = Y_j$

$$\lambda Y_j = \left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}} \sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \tag{A.0.5}$$

Insert for $\lambda$ from (39) and then rearrange such that:

$$\tau_{ij}p_i = \frac{\beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{-1}{\sigma}} Y_j}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}} \tag{A.0.6}$$

Raise both sides by $-\sigma$ and multiply by $\tau_{ij}p_i$:

$$(\tau_{ij}p_i)^{-\sigma}\tau_{ij}p_i = \left[\frac{\beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{-1}{\sigma}} Y_j}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}}\right]^{-\sigma} \tau_{ij}p_i \tag{A.0.7}$$

Rearrange:

$$(\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{Y_j^{-\sigma} c_{ij}\tau_{ij}p_i}{\left[\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{-\sigma}} \tag{A.0.8}$$

Then sum over all $i's$ such that:

$$\sum_{i=1}^{N}(\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{Y_j^{-\sigma}\sum_{i=1}^{N}\tau_{ij}p_i c_{ij}}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}} \tag{A.0.9}$$

where $\sum_{i=1}^{N}\tau_{ij}p_i c_{ij} = Y_j$, so that:

$$\sum_{i=1}^{N}(\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{Y_j^{1-\sigma}}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}} \tag{A.0.10}$$

Define $\left[\sum_{i=1}^{N}(\tau_{ij}p_i\beta_i)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} = P_j$ as a price index of country $j$ and rewrite the equation such that:

$$\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} = \frac{Y_j^{1-\sigma}}{P_j^{1-\sigma}} \tag{A.0.11}$$

Innsert this back into equation (44):

$$(\tau_{ij} p_i \beta_i)^{1-\sigma} = \frac{c_{ij} \tau_{ij} p_i}{Y_j} P_j^{1-\sigma} \tag{A.0.12}$$

Remember that the nominal value of exports from country $i$ to country $j$ in chapter 3 is given by $X_{ij} = \tau_{ij} p_i c_{ij}$. Innserting (48) into this expression yields the demand for goods from country $i$ by country $j$ consumers:

$$X_{ij} = \frac{(\tau_{ij} p_i \beta_i)^{1-\sigma}}{P_j^{1-\sigma}} Y_j \tag{A.0.13}$$

# B Abbreviations

| | |
|---|---|
| BRIC | Brasil Russia India China |
| CET | Common External Tariff |
| CIS | Commonwealth of Independent States |
| CISFTA | Commonwealth of Independent States Free Trade Agreement |
| CU | Customs Union |
| EEU | Eurasian Economic Union |
| EFTA | European Free Trade Agreement |
| EIA | Economic Integration Agreement |
| EU | European Union |
| EurAsEC | Eurasian Economic Community |
| FTA | Free Trade Agreement |
| GATT | General Agreement on Tariffs and Trade |
| GDP | Growth Domestic Product |
| IMF DOTS | International Monetary Fund Directions of Trade Statistics |
| NAFTA | North American Free Trade Agreement |
| PPP | Purchasing Power Parity |
| PTA | Preferential Trade Agreement |
| RTA | Regional Trade Agreement |
| SES | Single Economic Space |
| UN COMTRADE | United Nations International Trade Statistics Database |
| WTO | World Trade Organization |
| USSR | The Union of Soviet Socialist Republics |

# C List of countries in the dataset

| | | | |
|---|---|---|---|
| **Armenia** | **Czech Republic** | **Kazakhstan** | **Romania** |
| **Australia** | **Denmark** | **Kyrgyzstan** | **Russia** |
| **Austria** | **Estonia** | **Latvia** | **Slovakia** |
| **Azerbaijan** | **Finland** | **Lithuania** | **Slovenia** |
| **Belarus** | **France** | **Luxembourg** | **Spain** |
| **Belgium** | **Germany** | **Malta** | **Sweden** |
| **Bulgaria** | **Greece** | **Moldova** | **Tajikistan** |
| **Brasil** | **Hungary** | **Netherlands** | **Turkmenistan** |
| **China** | **India** | **New Zealand** | **Ukraine** |
| **Croatia** | **Ireland** | **Poland** | **United Kingdom** |
| **Cyprus** | **Italy** | **Portugal** | **United States** |
| | | | **Uzbekistan** |